US009160124B2

(12) **United States Patent**
**Colahan et al.**

(10) **Patent No.: US 9,160,124 B2**
(45) **Date of Patent: Oct. 13, 2015**

(54) **COMPLIANT MOUNT FOR CONNECTOR**

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(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 132 days.

(21) Appl. No.: **13/607,598**

(22) Filed: **Sep. 7, 2012**

(65) **Prior Publication Data**

US 2014/0073191 A1 Mar. 13, 2014

(51) **Int. Cl.**

| | |
|---|---|
| ***H01R 13/64*** | (2006.01) |
| ***H01R 31/06*** | (2006.01) |
| ***H01R 13/631*** | (2006.01) |

(52) **U.S. Cl.**
CPC ............ ***H01R 31/06*** (2013.01); ***H01R 13/6315*** (2013.01)

(58) **Field of Classification Search**
USPC .............................. 439/248, 929; 361/679.41
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 6,049,192 | A | 4/2000 | Kfoury et al. | |
| 6,193,546 | B1 | 2/2001 | Sadler | |
| 6,290,534 | B1 | 9/2001 | Sadler | |
| 6,716,058 | B2 | 4/2004 | Youn | |
| 6,898,080 | B2 | 5/2005 | Yin et al. | |
| 6,994,575 | B1 | 2/2006 | Clark et al. | |
| 7,014,486 | B1 * | 3/2006 | Wu et al. | 439/248 |
| 7,066,752 | B2 * | 6/2006 | Hsu et al. | 439/248 |
| 7,238,042 | B2 | 7/2007 | Chen et al. | |
| 7,473,141 | B2 | 1/2009 | Liao | |
| 7,485,007 | B1 | 2/2009 | Nee | |
| 7,488,215 | B2 | 2/2009 | Mayette et al. | |
| 7,513,801 | B2 | 4/2009 | Cheng et al. | |

(Continued)

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| AU | 2012101888 | A4 | 2/2013 |
| CN | 102610975 | A | 7/2012 |

(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion mailed on Jun. 13, 2013 for PCT Patent Application No. PCT/US2013/034597, 12 pages.

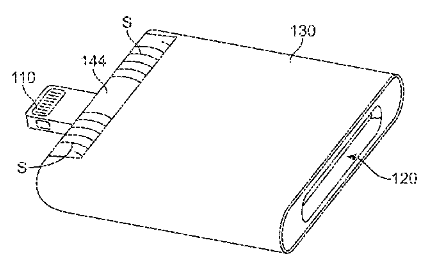
(Continued)

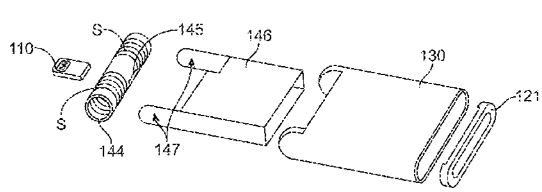
*Primary Examiner* — Hien Vu
(74) *Attorney, Agent, or Firm* — Kilaptrick Townsend & Stockton LLP

(57) **ABSTRACT**

A compliant mount for use in a connector or connection adapter is disclosed. The compliant mount may be used in a connection between a portable electronic device and another electronic device, such as a docking station. A compliant mount connector adapter may include a first end connector engageable with a portable device and a second end connector engageable with another device, the first and second end connectors coupled with a compliant mount allowing movement of the first end connector engaged with the portable device relative to the second end connector when engaged within the other electronic device. The compliant mount may include any or all of: elastomers, springs, torsion bars, elastomers, rigid members or housing, ball and socket joints, resilient bendable members, and dongles to allow for controlled resistance to bending or torsional forces applied to the portable device when connected to the other electronic device with the connector adapter.

**15 Claims, 28 Drawing Sheets**



(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 7,538,792 | B2 | 5/2009 | Takahashi |
| 7,580,225 | B2 | 8/2009 | Hanrahan et al. |
| 7,684,186 | B2 | 3/2010 | Chang |
| 7,719,830 | B2 | 5/2010 | Howarth et al. |
| 7,744,423 | B2 | 6/2010 | Funahashi |
| 7,789,711 | B2 | 9/2010 | Wu |
| 7,832,645 | B2 | 11/2010 | Chen et al. |
| 7,850,484 | B2 | 12/2010 | Hayashi et al. |
| 7,931,494 | B2 | 4/2011 | Long |
| 7,933,117 | B2 | 4/2011 | Howarth et al. |
| 8,083,195 | B2 | 12/2011 | Osada |
| 8,113,873 | B1 | 2/2012 | Sarraf |
| 8,139,353 | B2 | 3/2012 | Slaby et al. |
| 8,152,561 | B2 | 4/2012 | Long |
| 8,210,871 | B2 | 7/2012 | Neu et al. |
| 8,323,040 | B2 | 12/2012 | Prest |
| 8,355,690 | B2 | 1/2013 | Krampf et al. |
| 8,366,480 | B2 | 2/2013 | Neu et al. |
| 8,535,102 | B1 | 9/2013 | Colahan et al. |
| 2002/0024794 | A1 | 2/2002 | Lin et al. |
| 2002/0032042 | A1 | 3/2002 | Poplawsky et al. |
| 2003/0008566 | A1 | 1/2003 | Kato et al. |
| 2003/0017746 | A1* | 1/2003 | Lee ................................ 439/638 |
| 2003/0148740 | A1 | 8/2003 | Yau et al. |
| 2006/0063434 | A1 | 3/2006 | Bergmann et al. |
| 2006/0141856 | A1 | 6/2006 | Chen et al. |
| 2006/0172607 | A1 | 8/2006 | Bangert |
| 2006/0250764 | A1 | 11/2006 | Howarth et al. |
| 2006/0258224 | A1 | 11/2006 | Liao |
| 2006/0276083 | A1 | 12/2006 | Sun |
| 2007/0153463 | A1 | 7/2007 | Choi |
| 2008/0259550 | A1 | 10/2008 | Lien |
| 2008/0293303 | A1 | 11/2008 | Liao |
| 2009/0009957 | A1 | 1/2009 | Crooijmans et al. |
| 2010/0009574 | A1 | 1/2010 | Shi et al. |
| 2010/0081337 | A1 | 4/2010 | Dorogusker et al. |
| 2011/0070757 | A1 | 3/2011 | Krampf et al. |
| 2011/0070777 | A1 | 3/2011 | Krampf et al. |
| 2011/0134601 | A1 | 6/2011 | Sa |
| 2011/0250786 | A1 | 10/2011 | Reid |
| 2012/0034819 | A1 | 2/2012 | Chen |
| 2012/0063188 | A1 | 3/2012 | Hotta et al. |
| 2013/0012041 | A2 | 1/2013 | Krampf et al. |

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| CN | 202384548 | U | 8/2012 |
| EP | 0 755 618 | B1 | 6/2000 |
| WO | 2008/039464 | A1 | 4/2008 |

OTHER PUBLICATIONS

Chinese Notice of Allowance mailed on May 22, 2013 for Chinese Patent Application No. 201320029920.7, with English translation of allowed claims, 6 pages.

Innovation Patent Certificate of Examination issued on Jun. 26, 2013 for Australian Patent Application No. 2012101888, 2 pages.

Certificate of Registration for German Patent Application No. 20 2013 000 042.2, mailed Apr. 9, 2013, 1 page.

Australian Office Action mailed on Nov. 3, 2014 for AU Patent Application No. 2013202659, 6 pages.

Chinese Office Action mailed on May 4, 2015 for CN Patent Application No. 201310125899.5, with English translation, 25 pages.


* cited by examiner

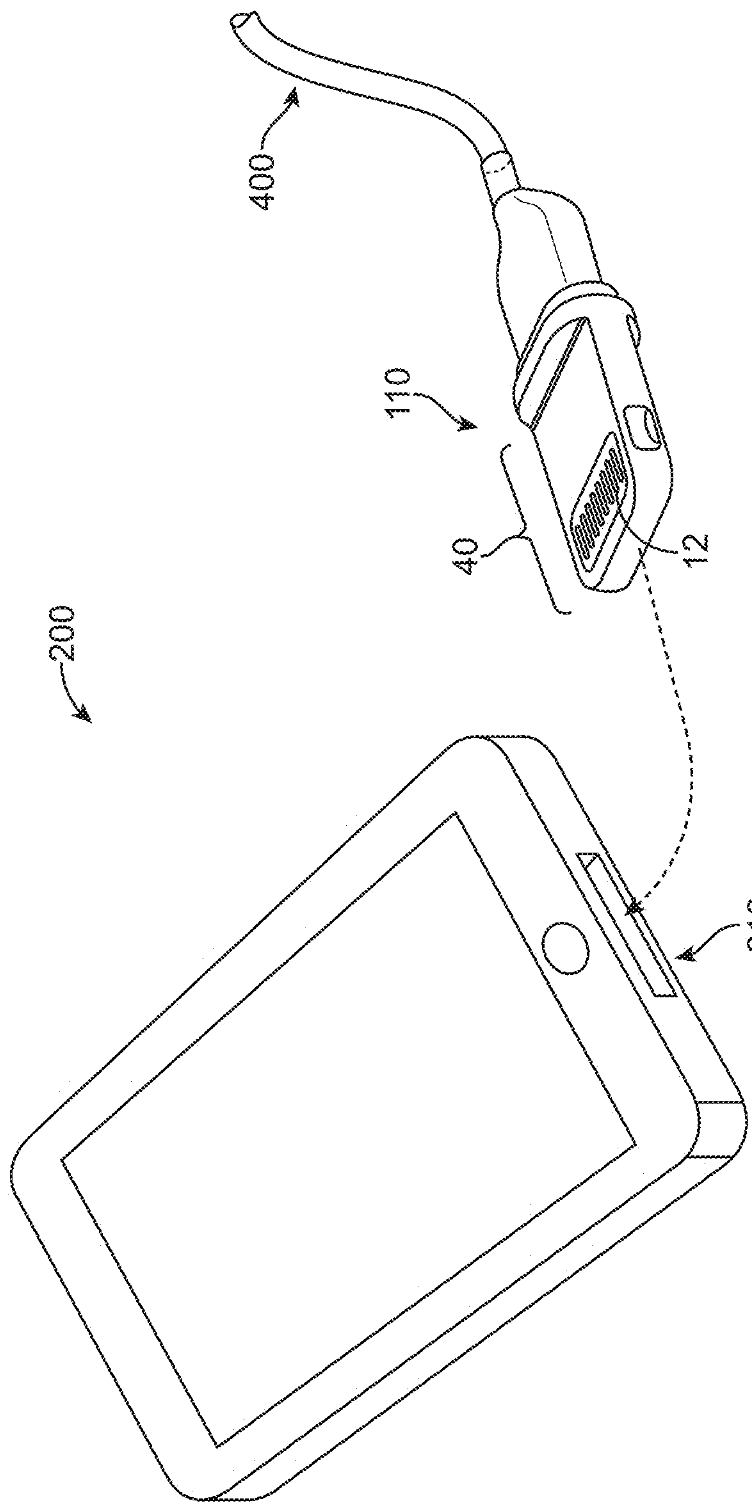



FIG. 1A

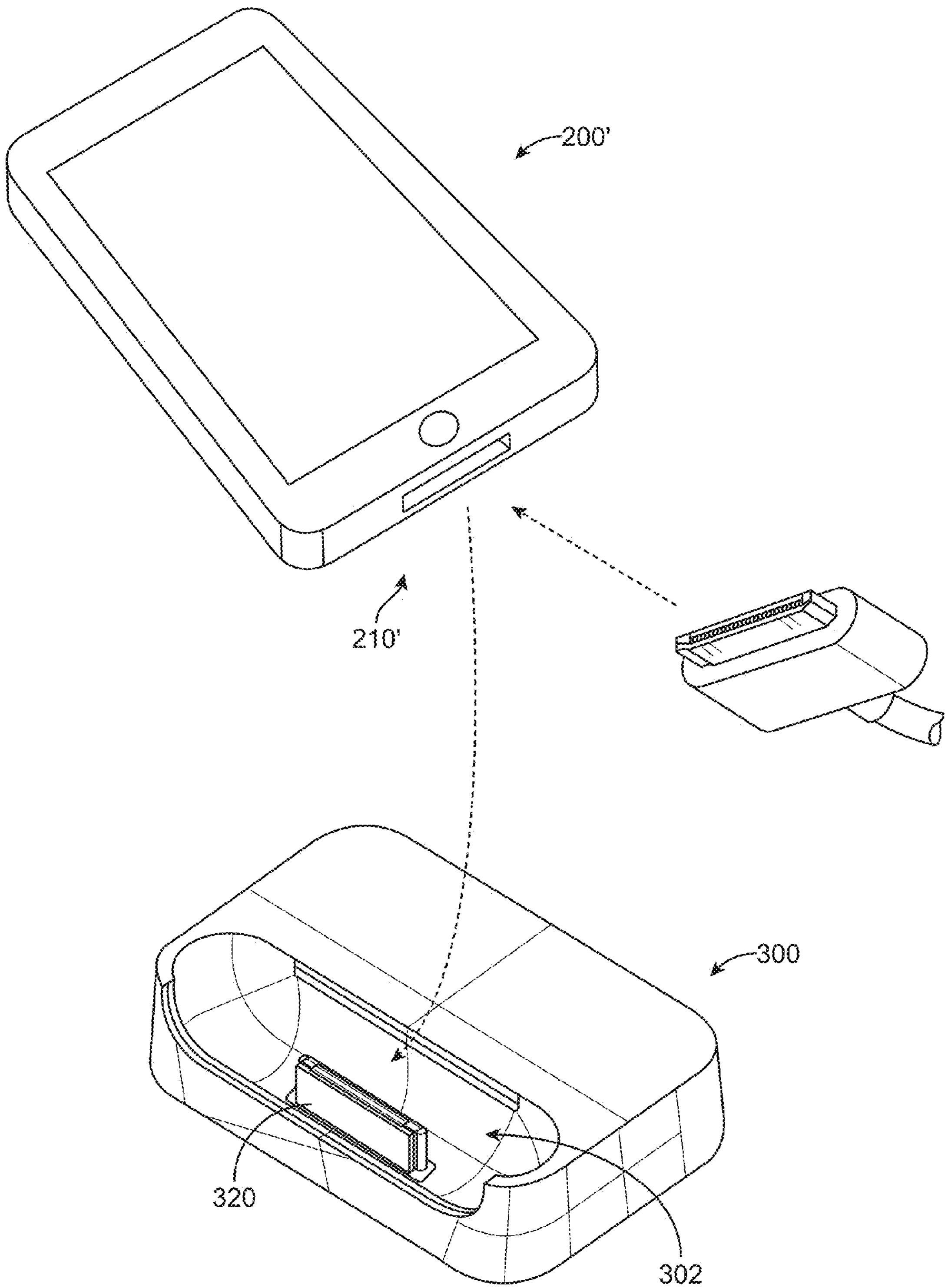



FIG. 1B

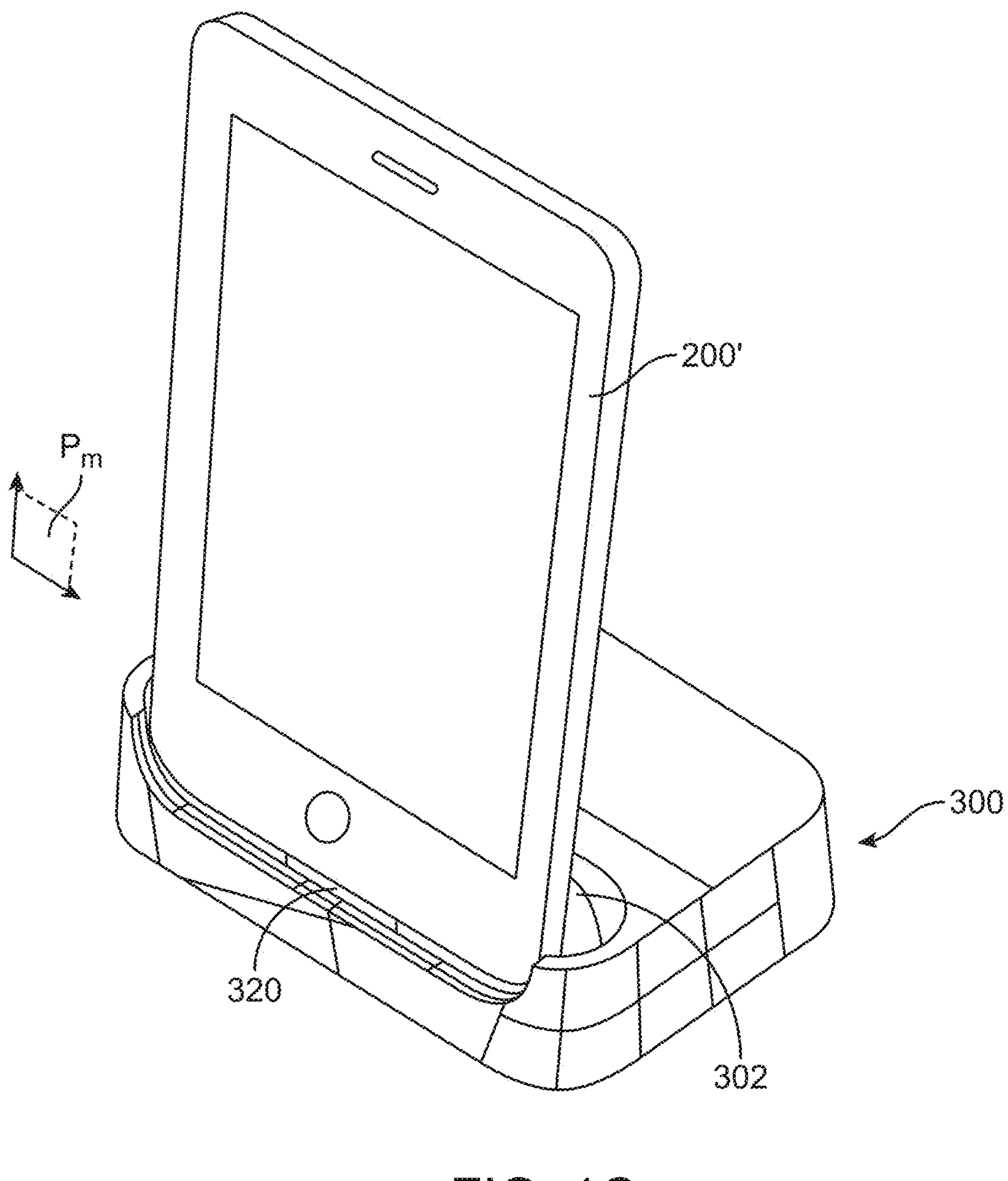



FIG. 1C

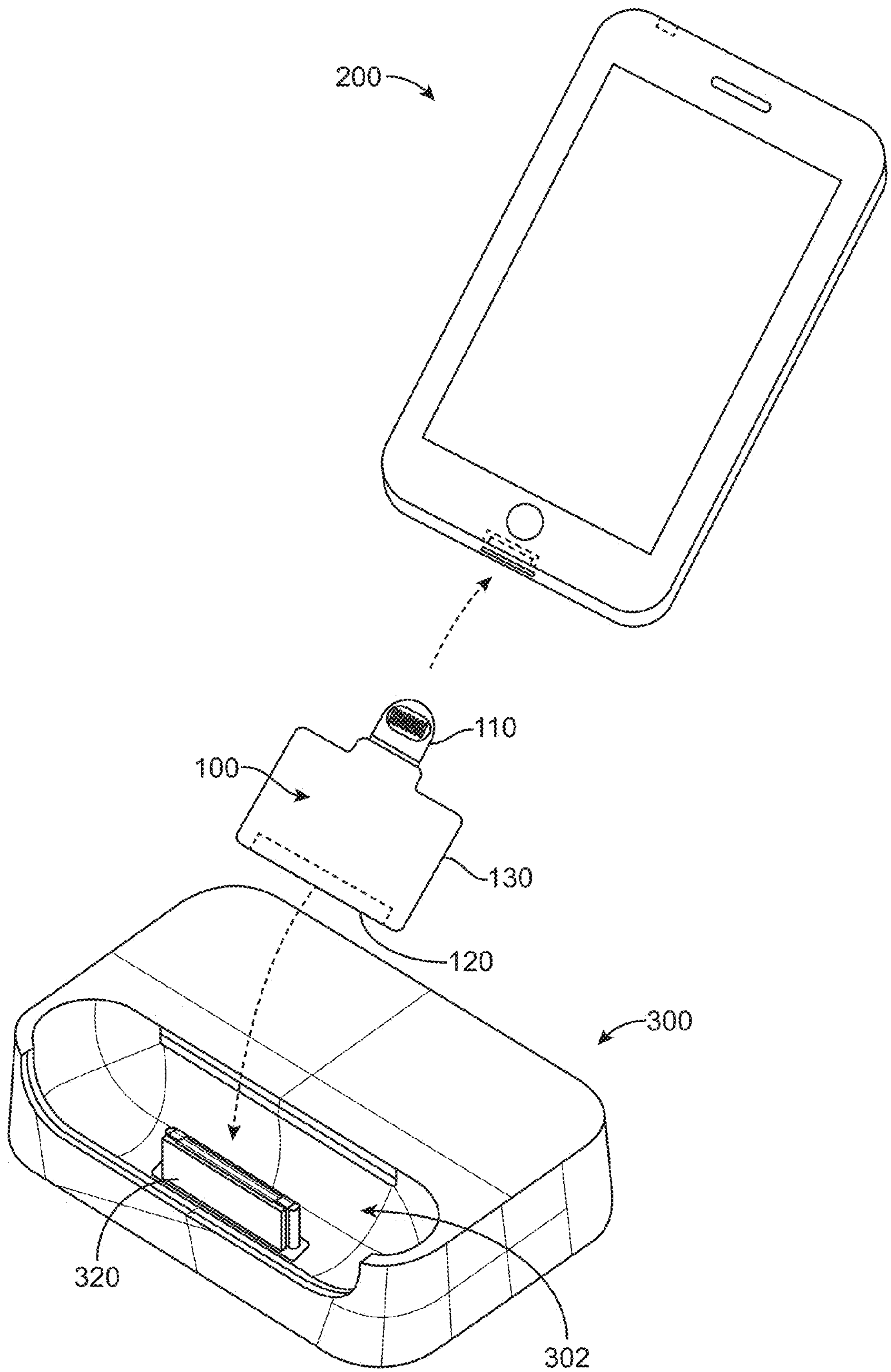



FIG. 2A

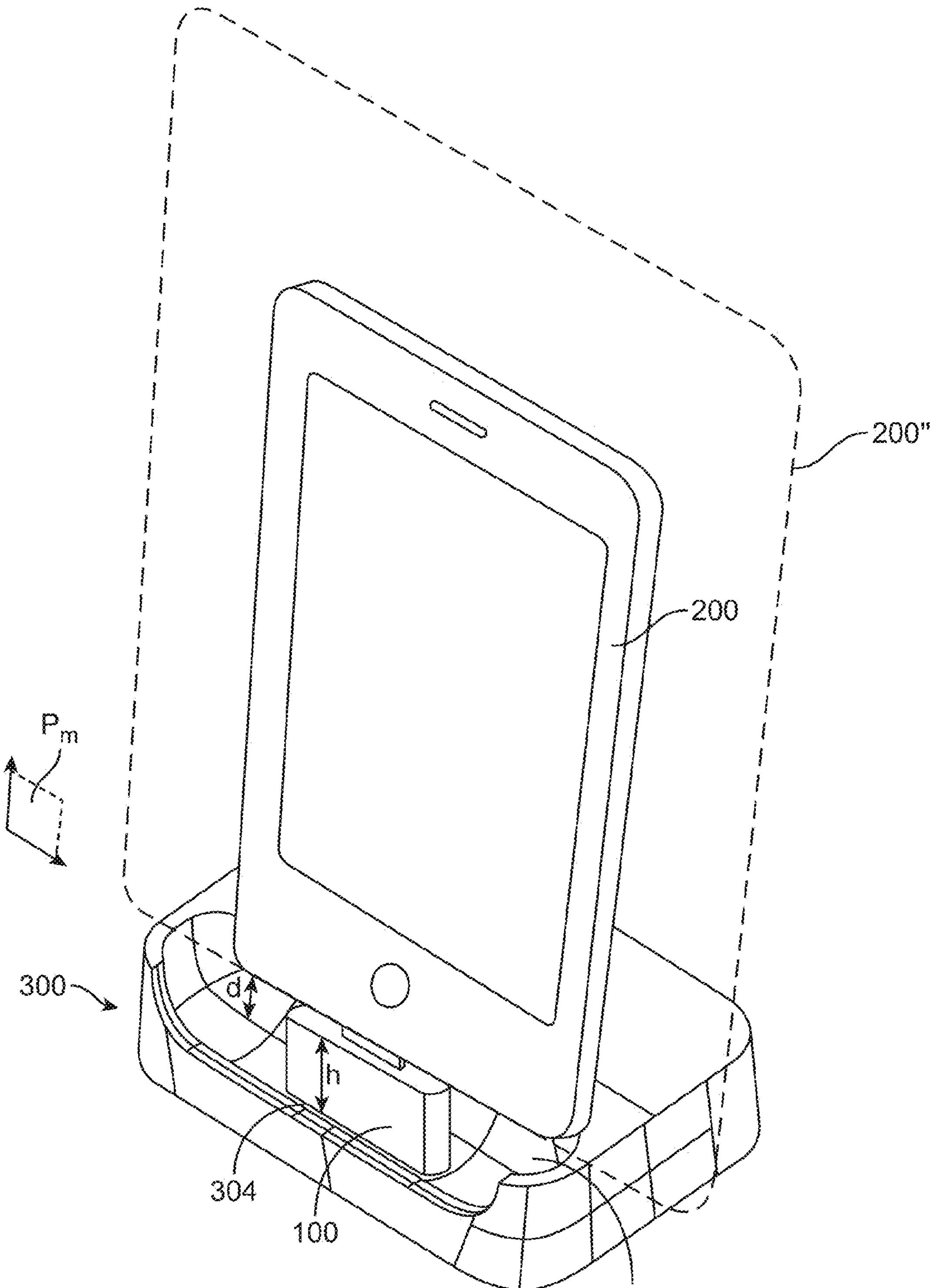



FIG. 2B

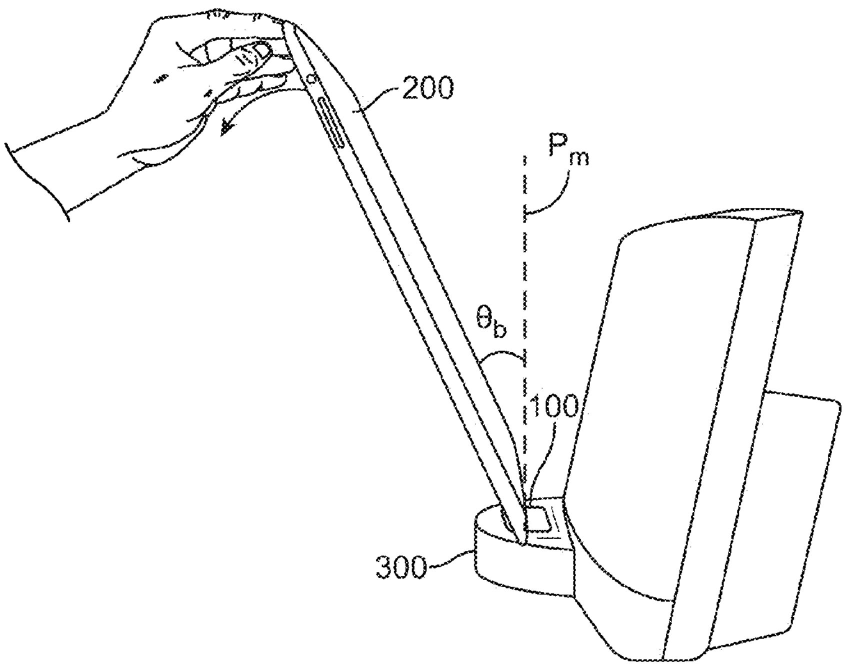



FIG. 2C

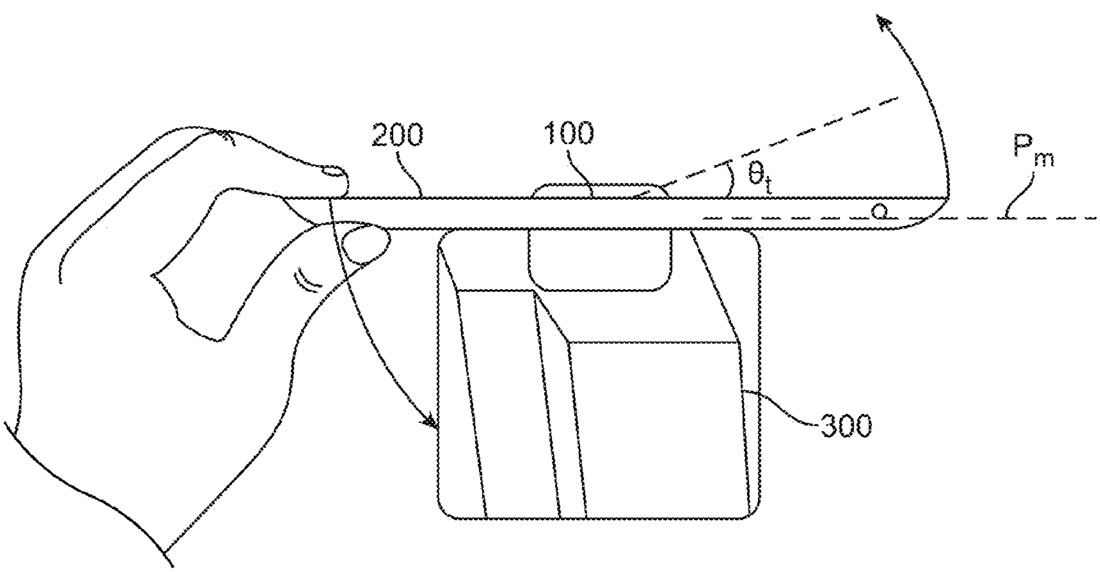



FIG. 2D

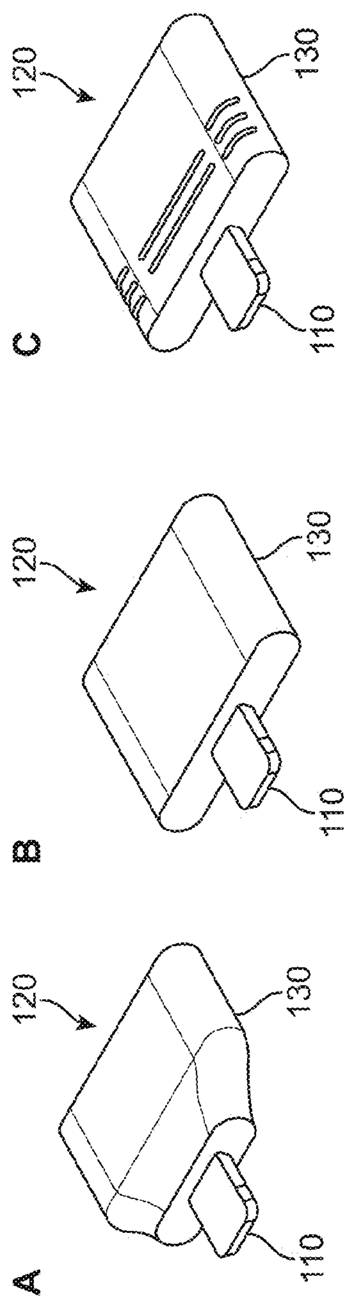



FIG. 3A

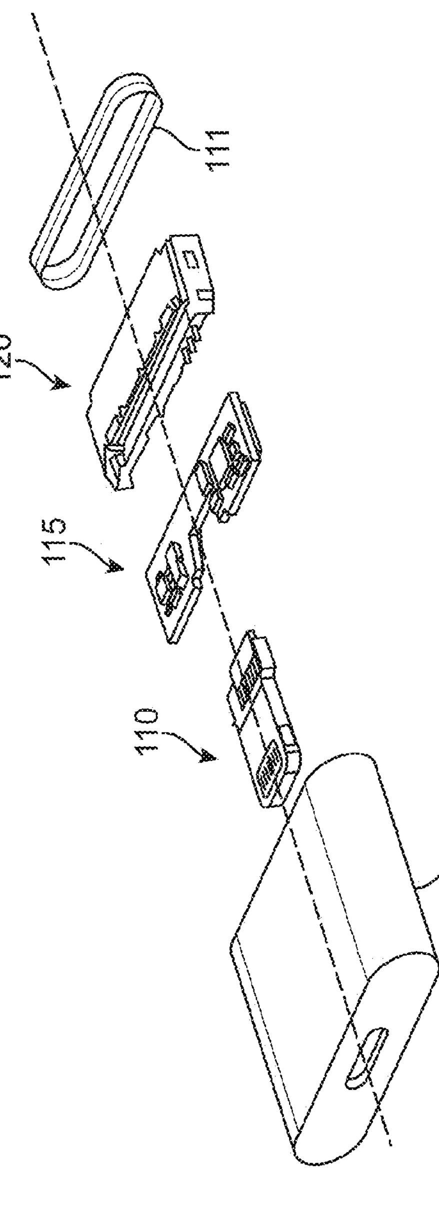
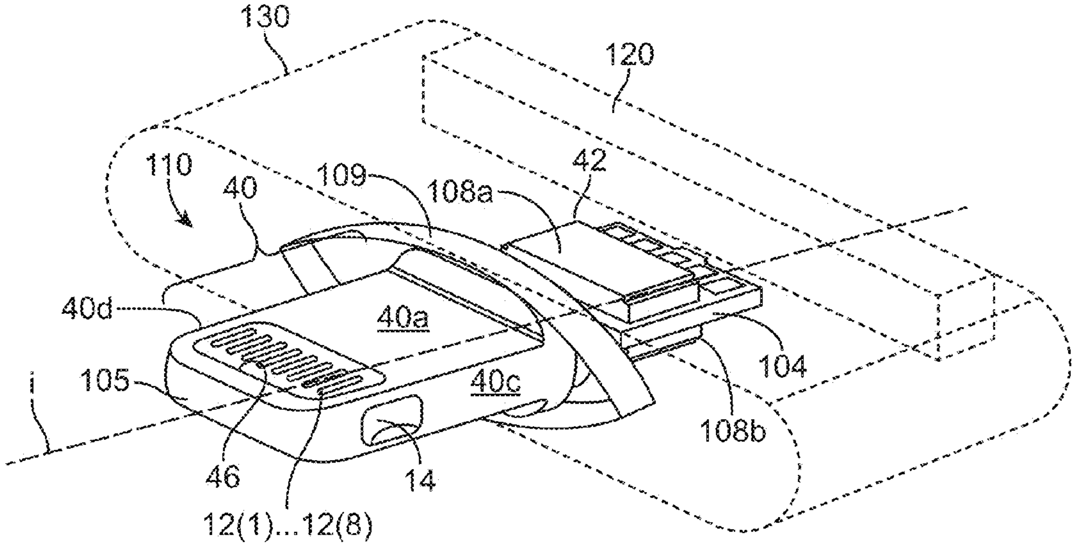



FIG. 3B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12(1)...12(8)

FIG. 3C

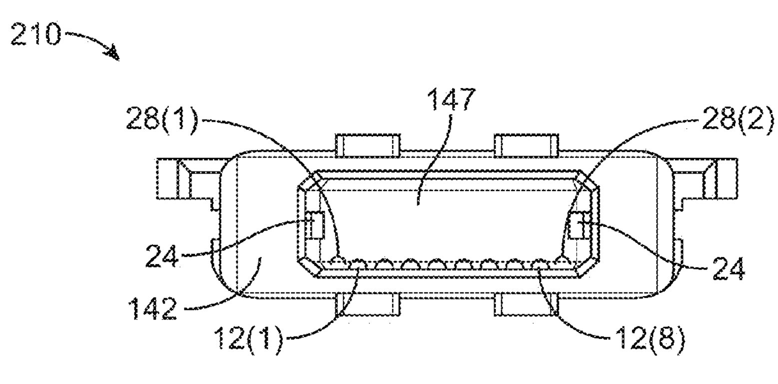
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FIG. 3D

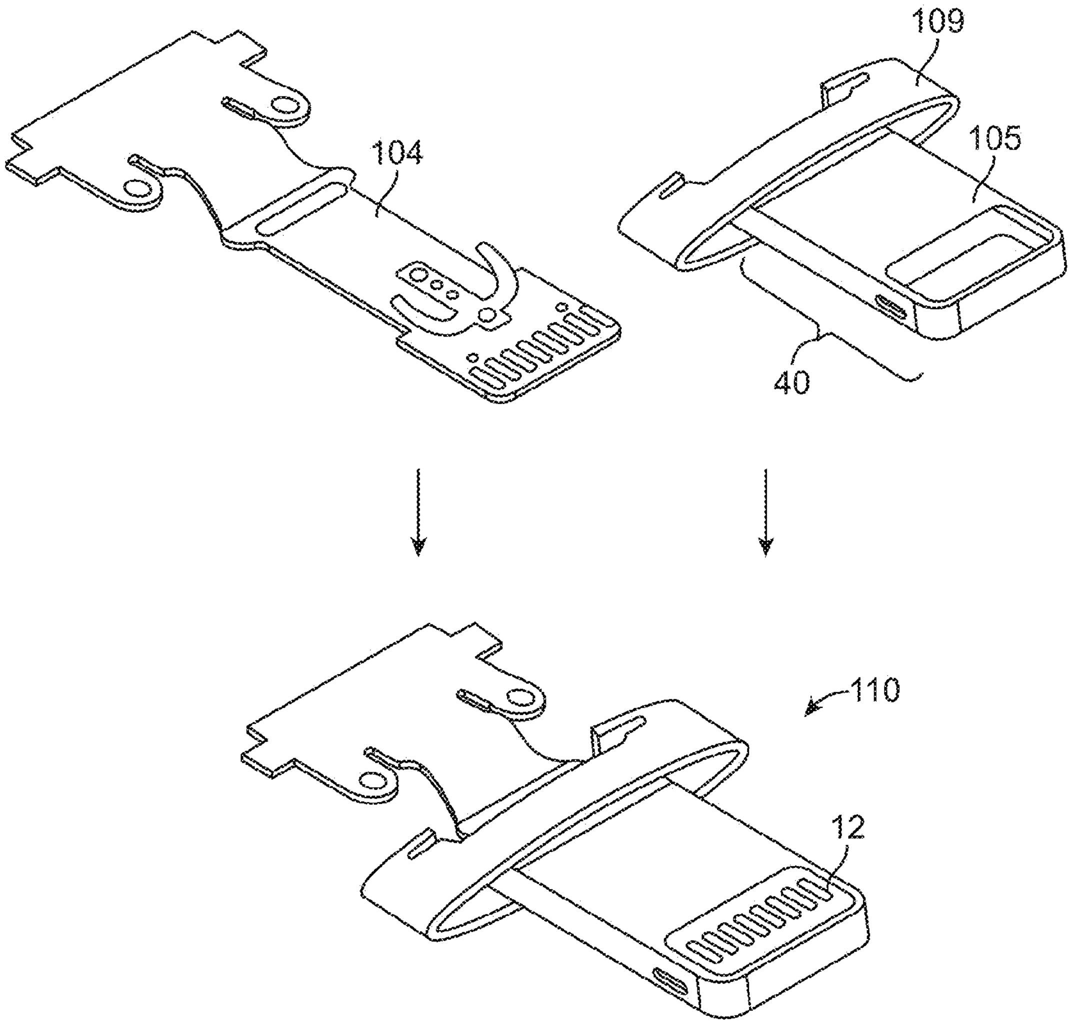



FIG. 3E

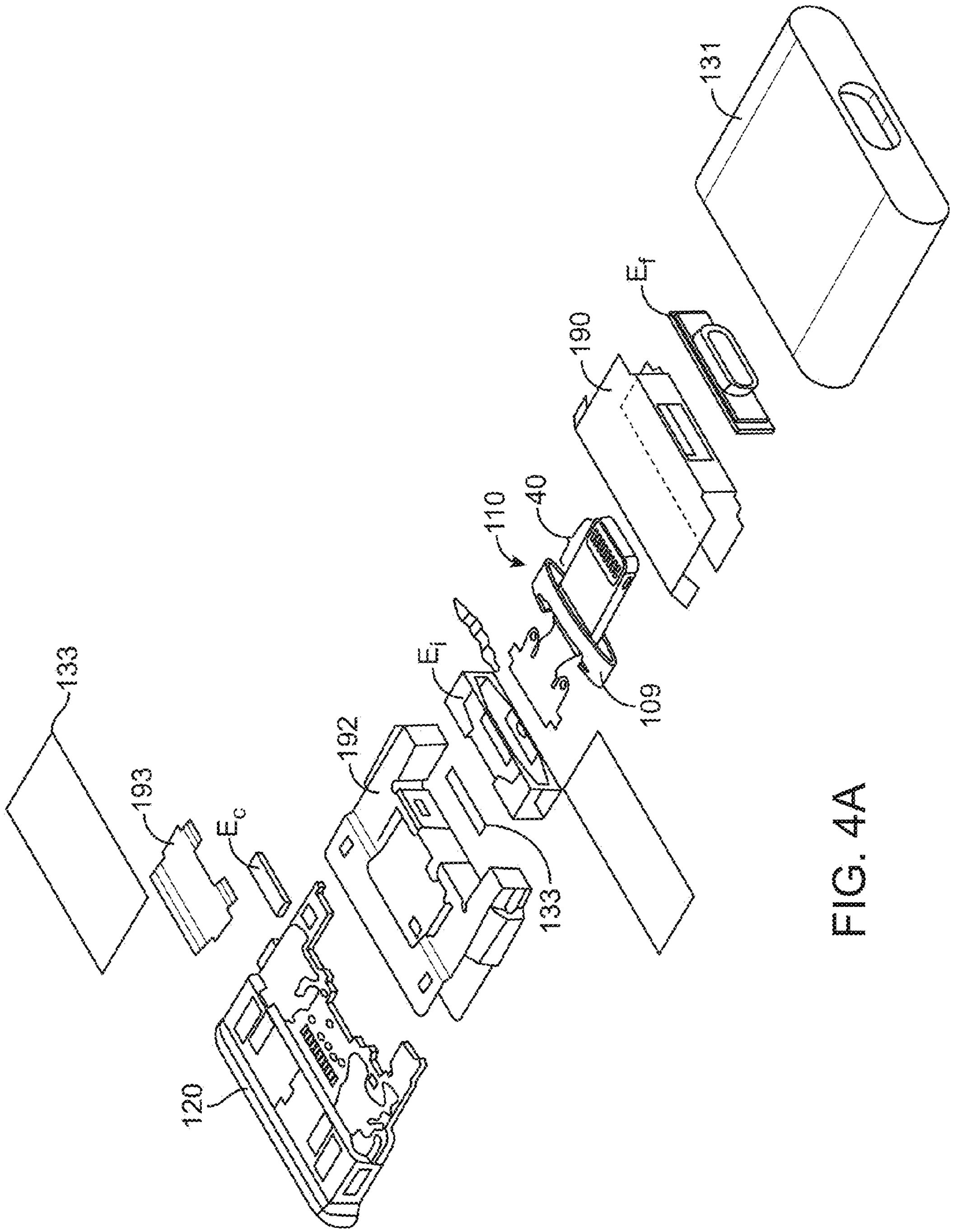
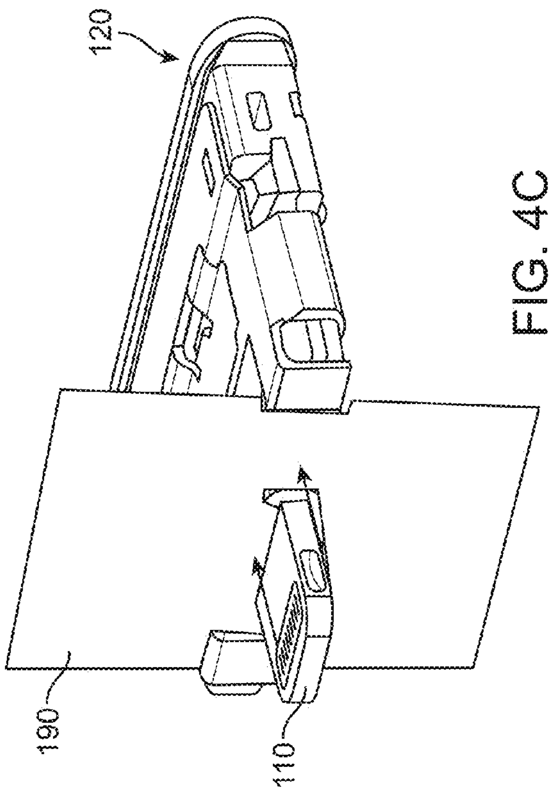



FIG. 4A

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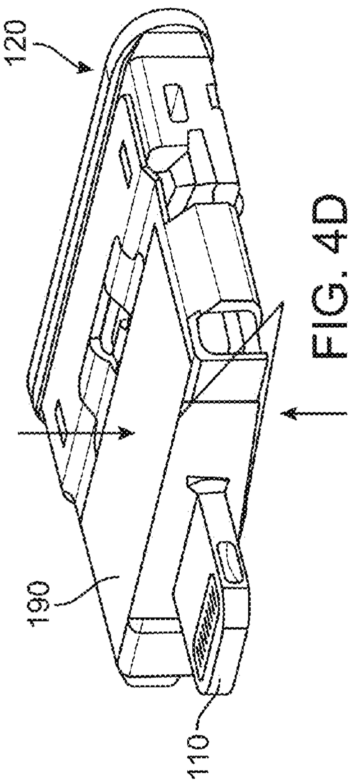
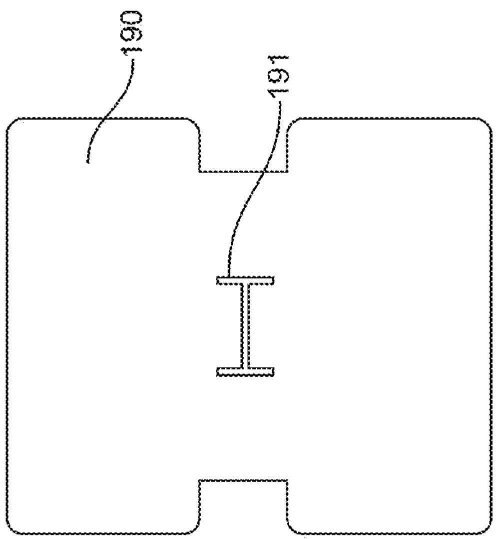



FIG. 4D



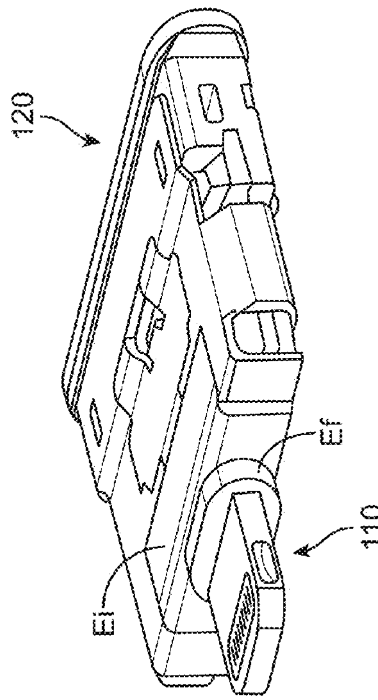




FIG. 4B

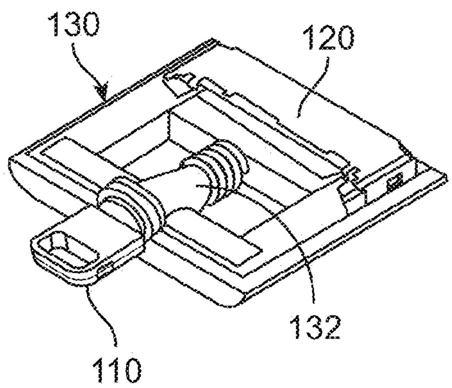



FIG. 5A

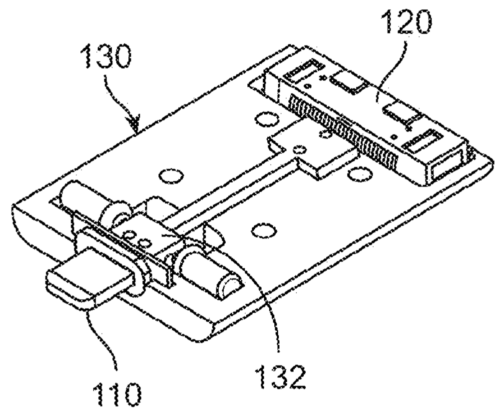



FIG. 5B

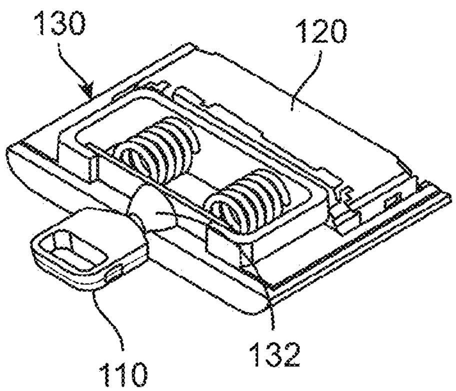



FIG. 5C

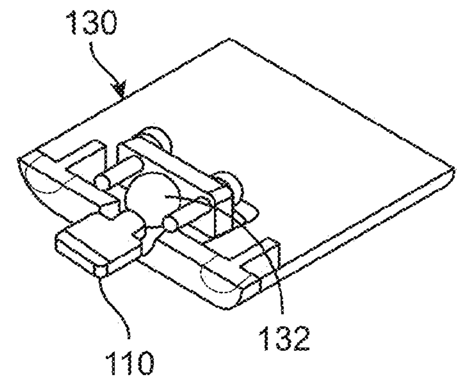



FIG. 5D

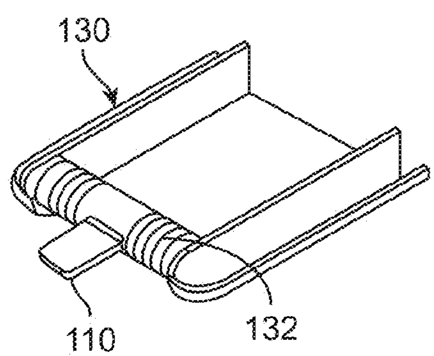



FIG. 5E

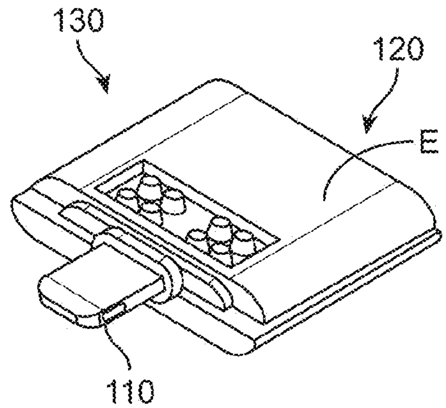



FIG. 6A

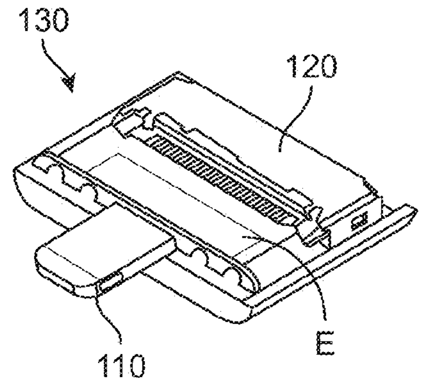



FIG. 6B

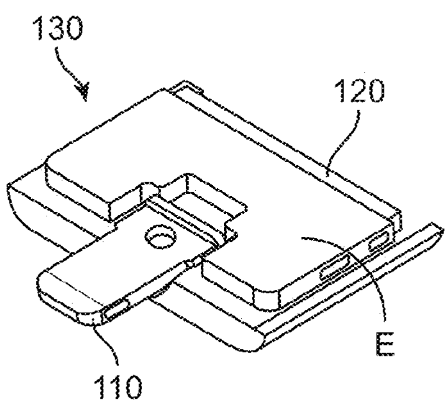



FIG. 6C

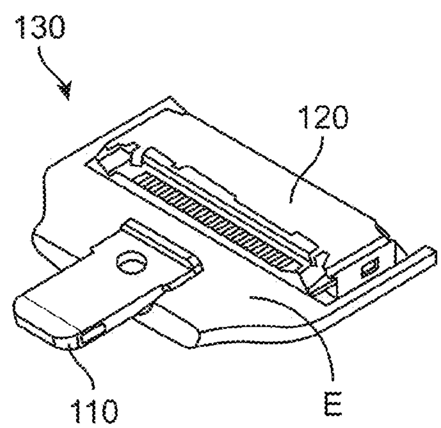



FIG. 6D

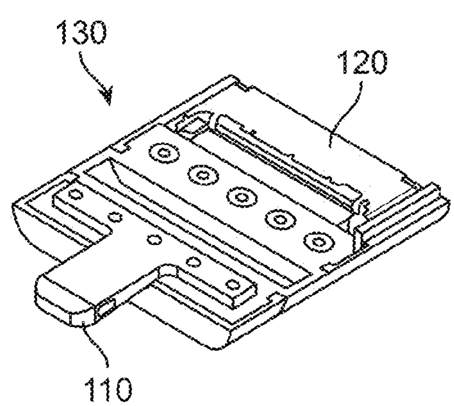



FIG. 6E

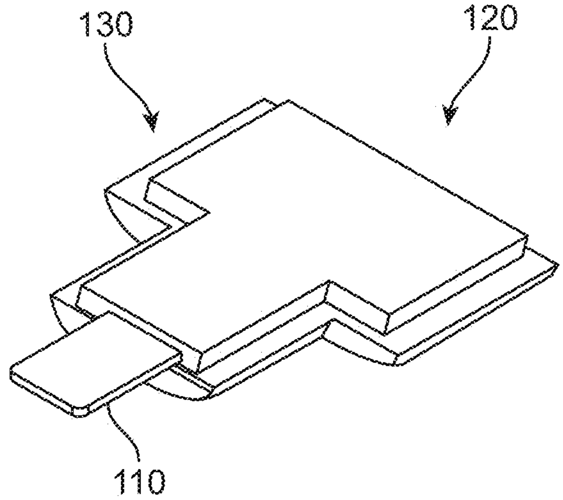



FIG. 7A

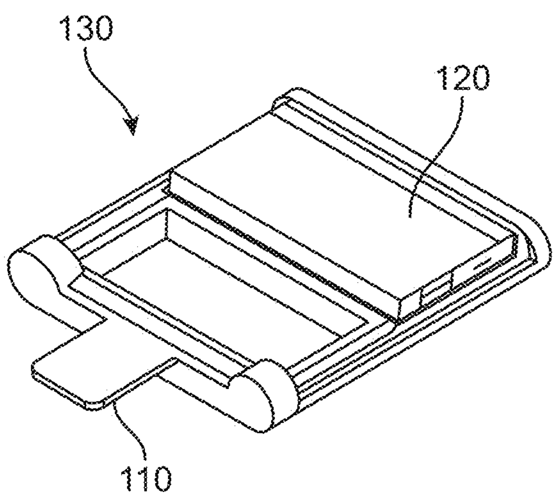



FIG. 7B

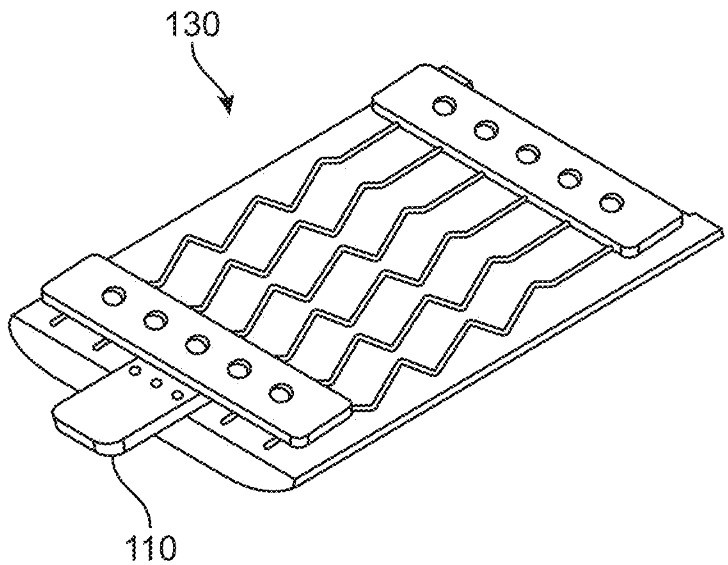



FIG. 8A

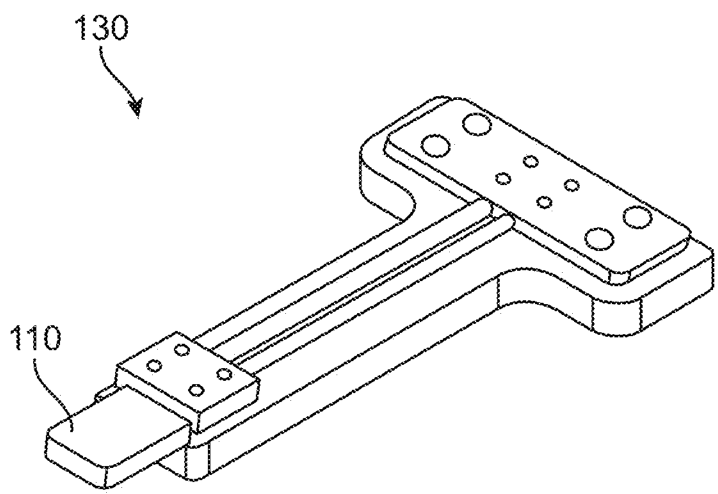



FIG. 8B

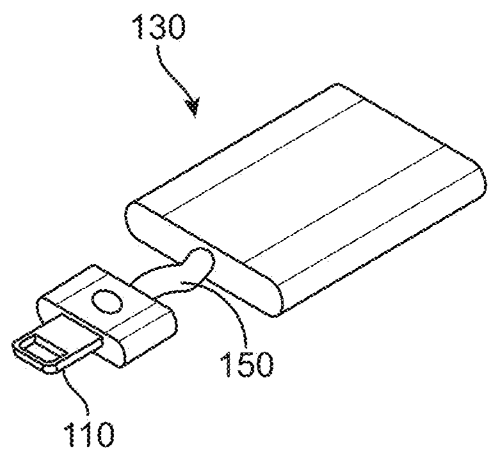



FIG. 9

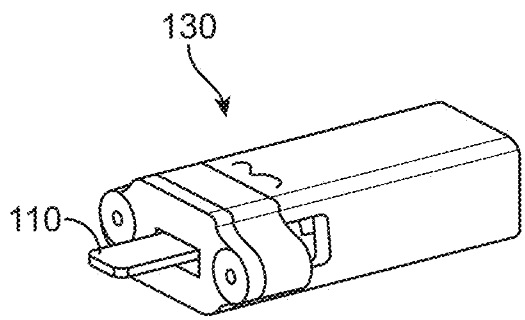



FIG. 10A

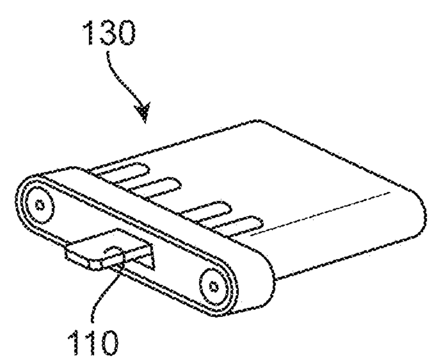



FIG. 10B

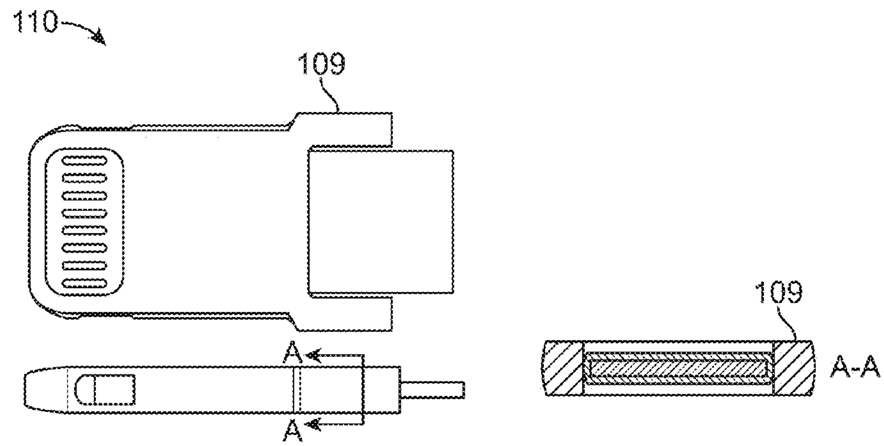



FIG. 11A

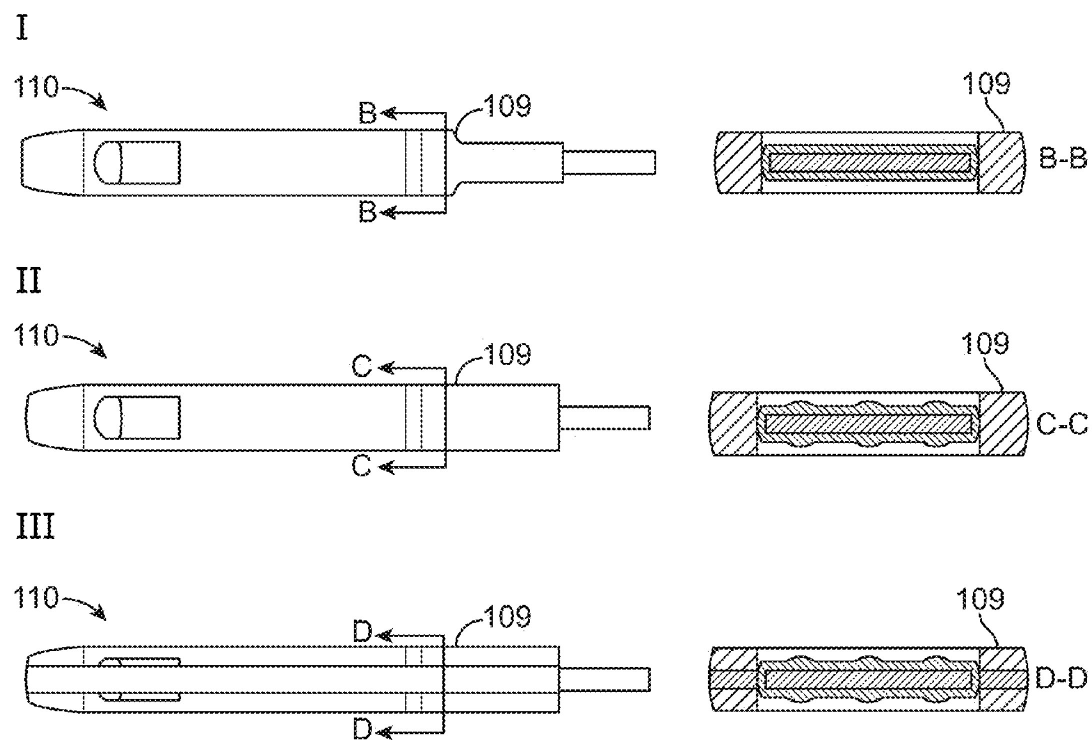



FIG. 11B

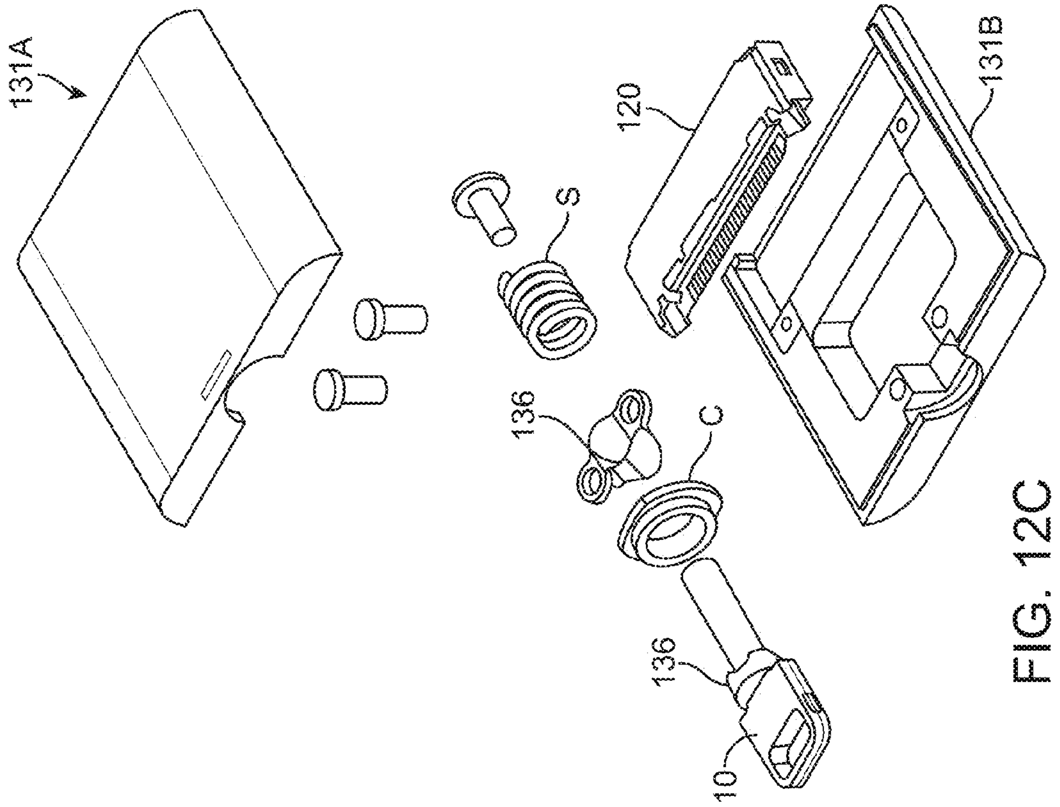



FIG. 12C

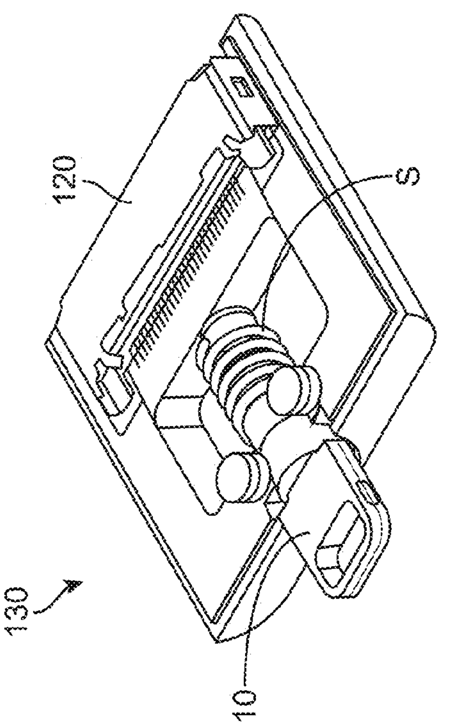



FIG. 12A

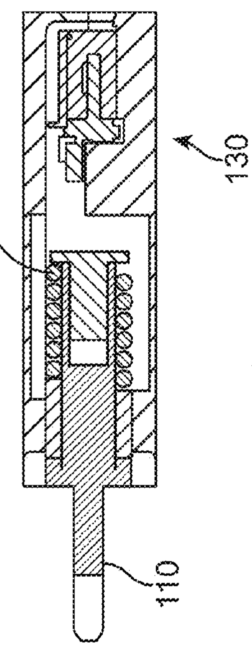



FIG. 12B

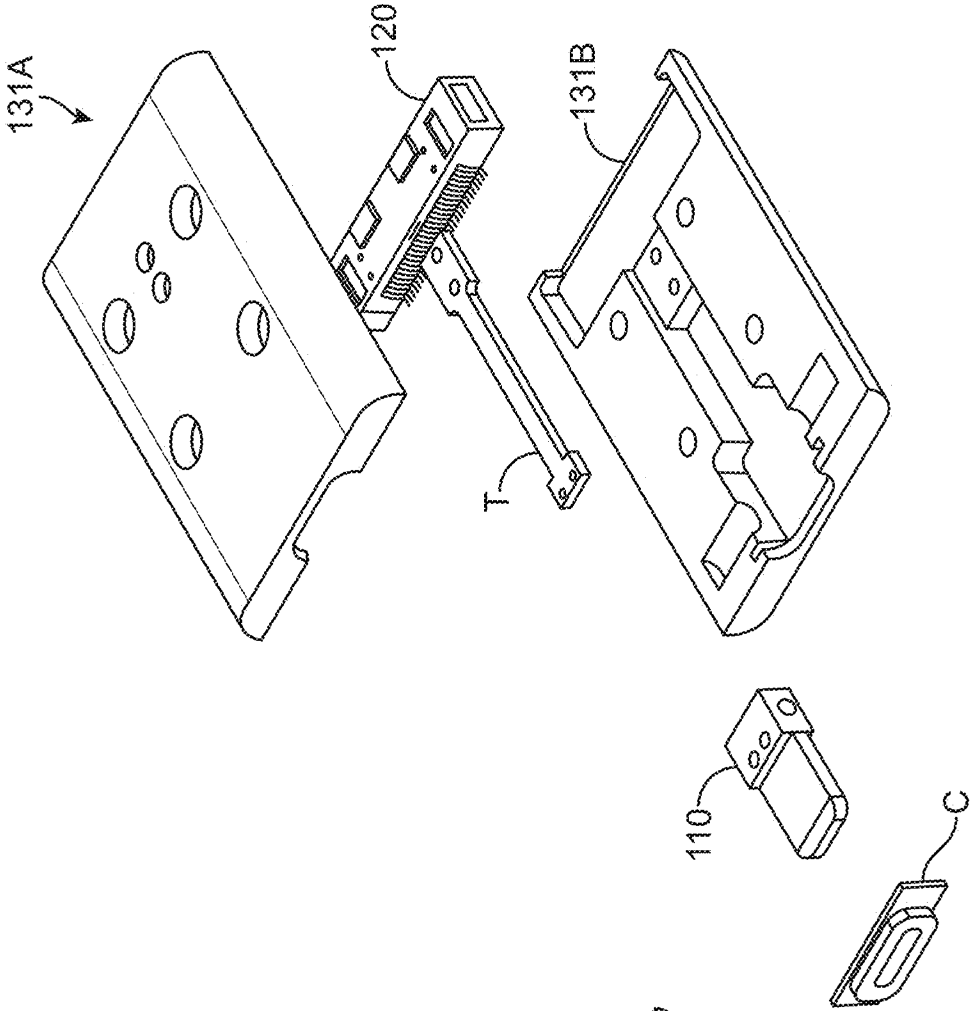



FIG. 13B

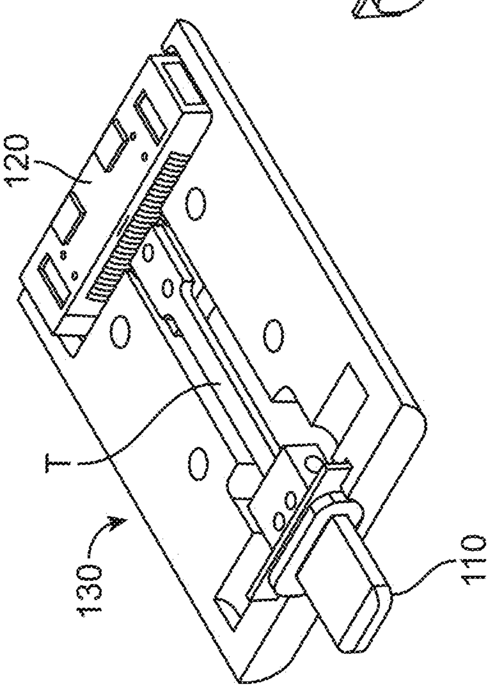



FIG. 13A

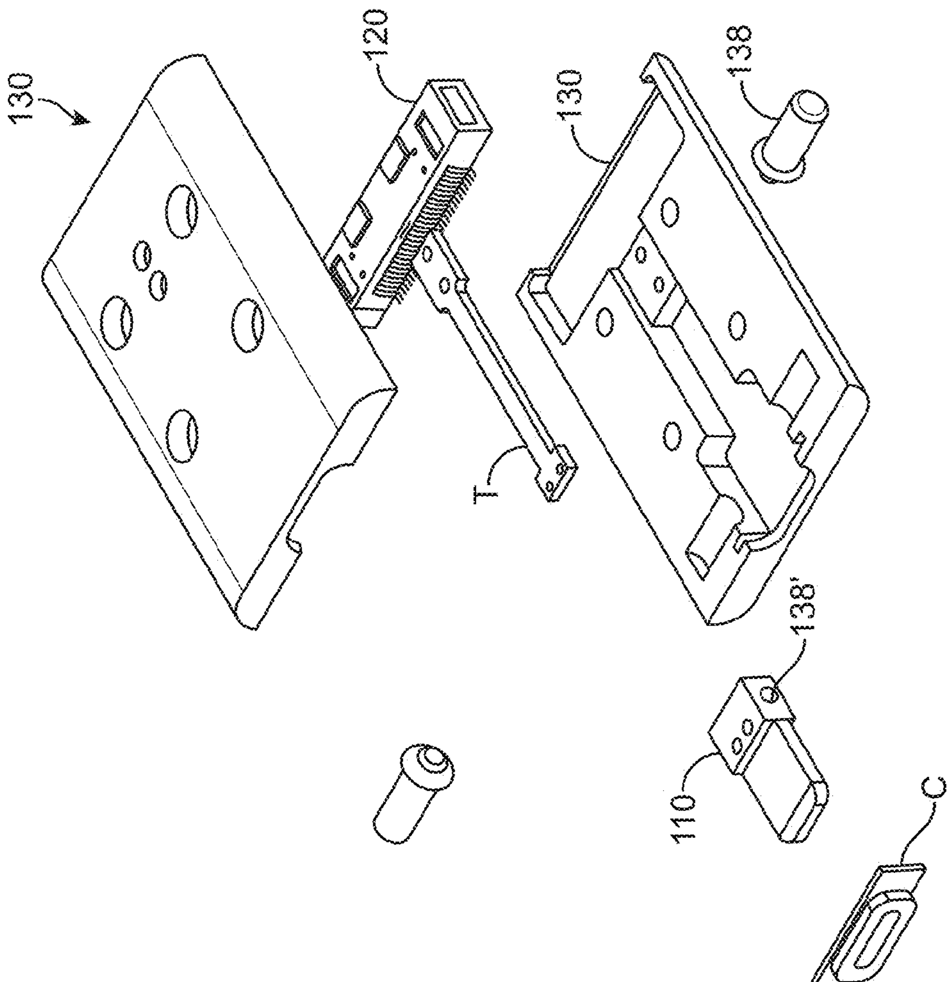



FIG. 14B

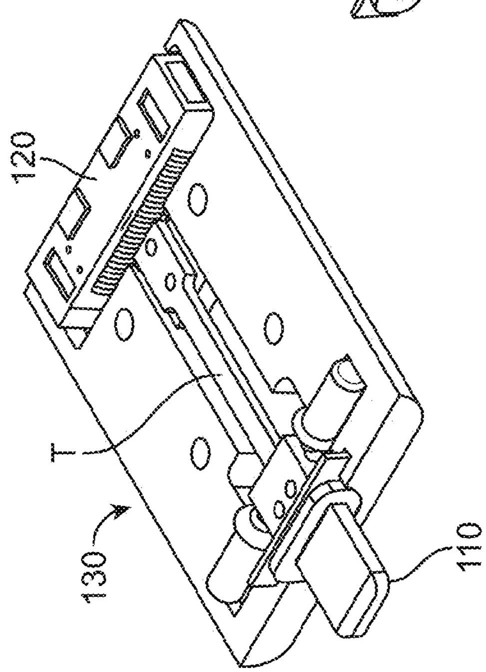



FIG. 14A

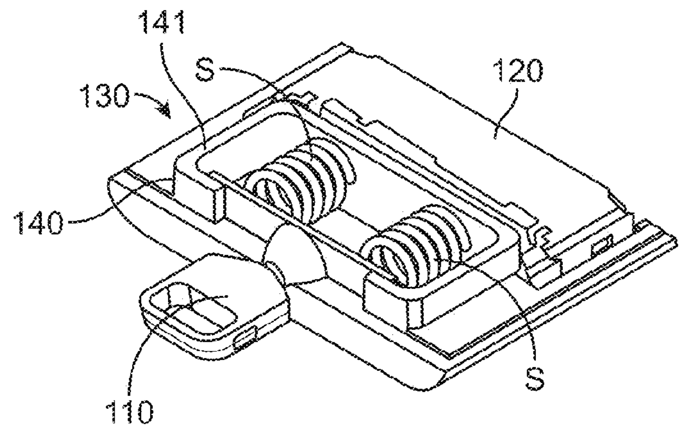



FIG. 15A

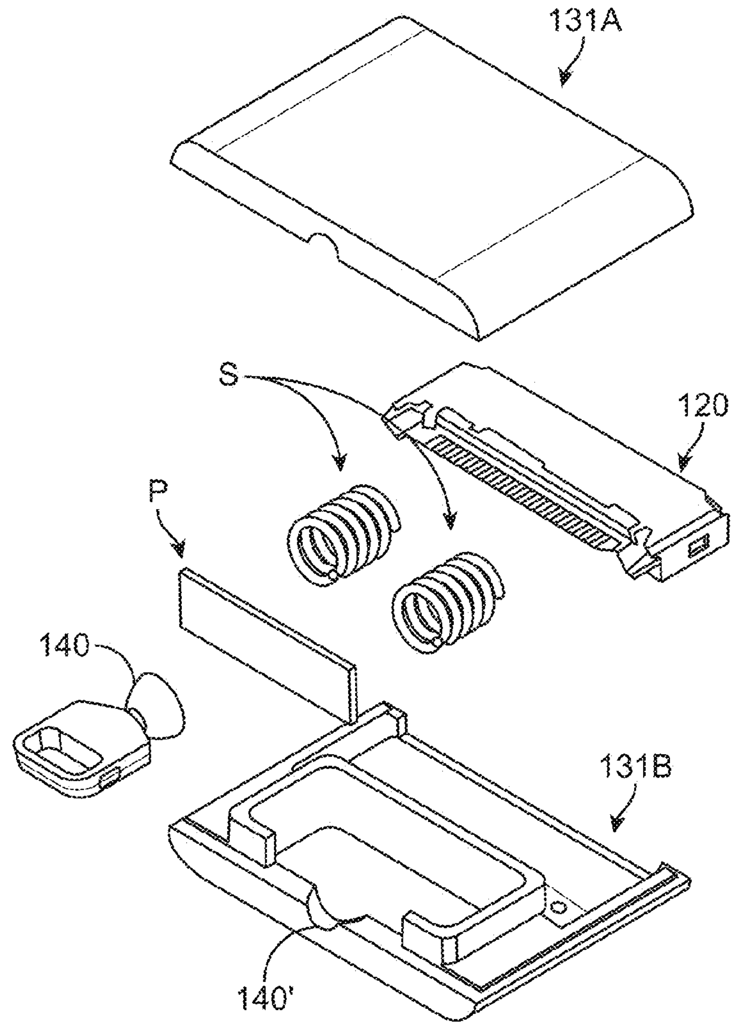



FIG. 15B

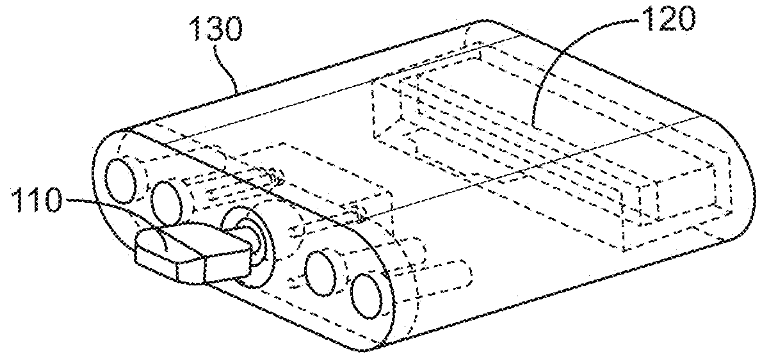



FIG. 16A

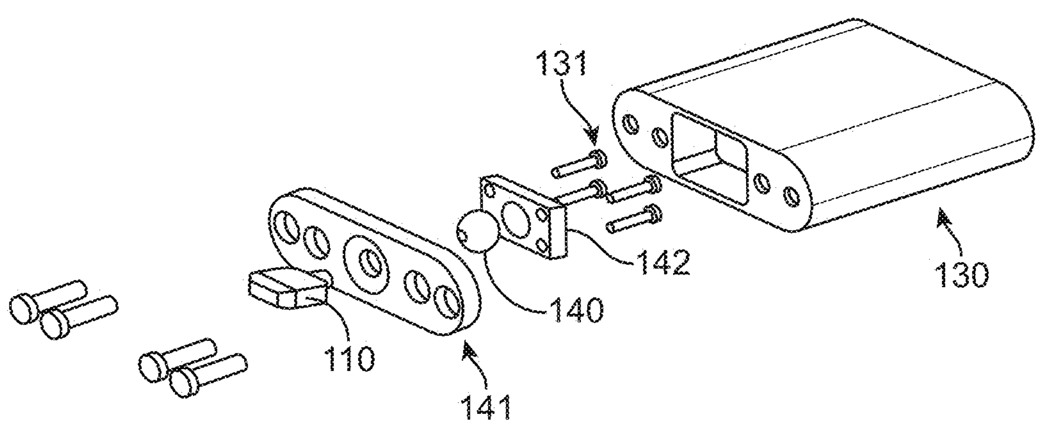



FIG. 16B

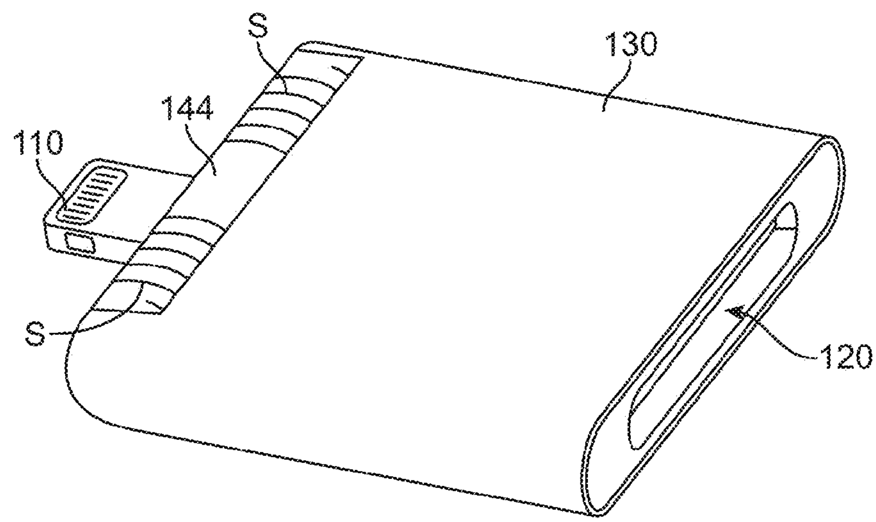



FIG. 17A-1

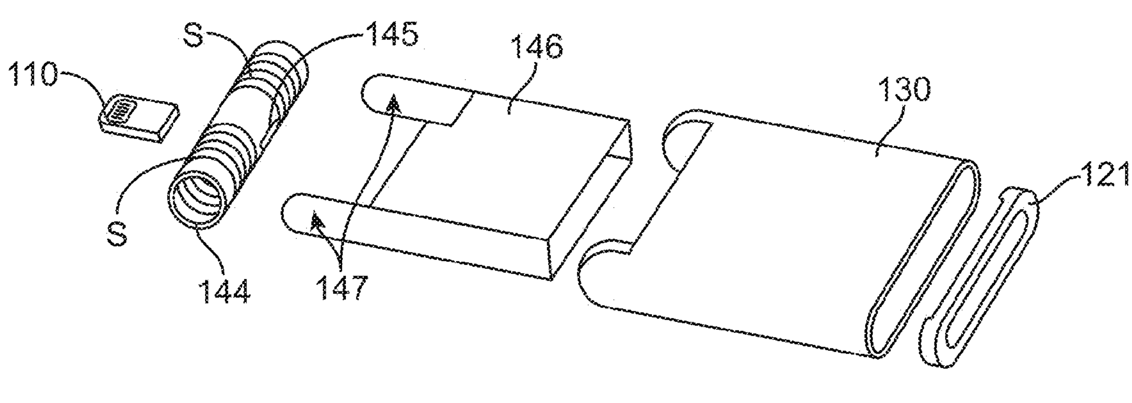



FIG. 17A-2

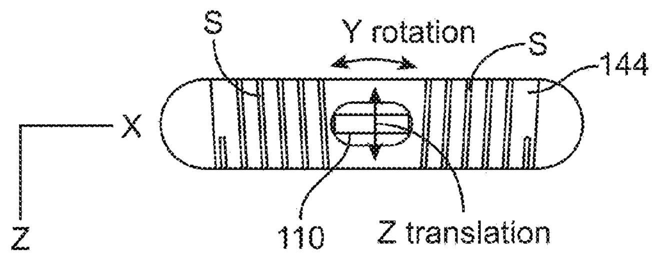



FIG. 17B-1

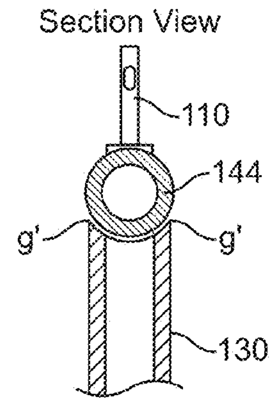



FIG. 17B-3

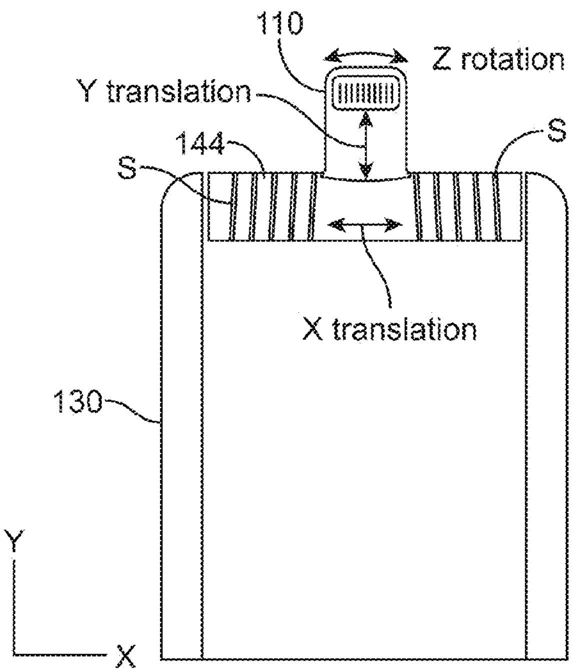



FIG. 17B-2

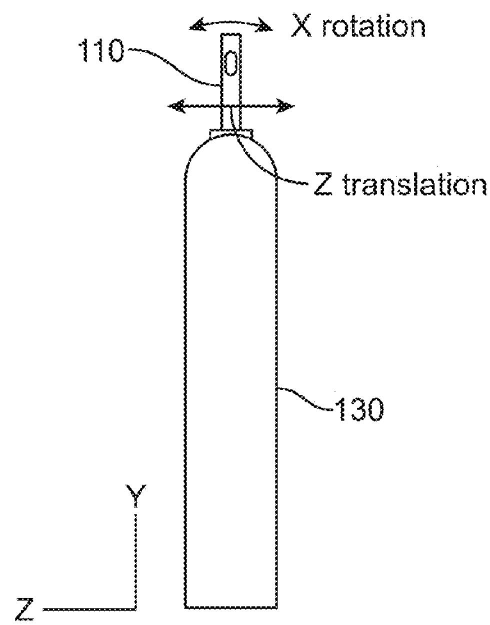



FIG. 17B-4

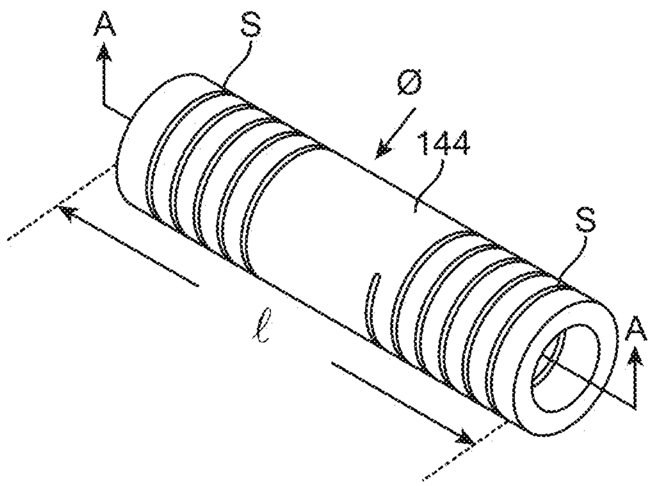



FIG. 17C-1

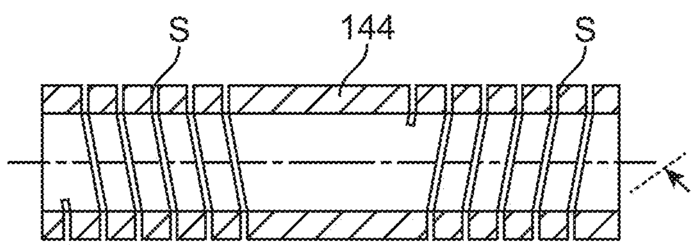



FIG. 17C-2

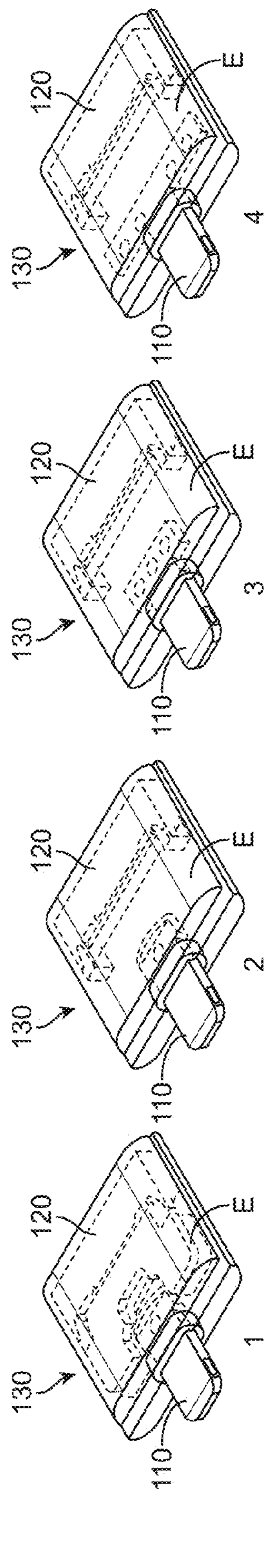



FIG. 18

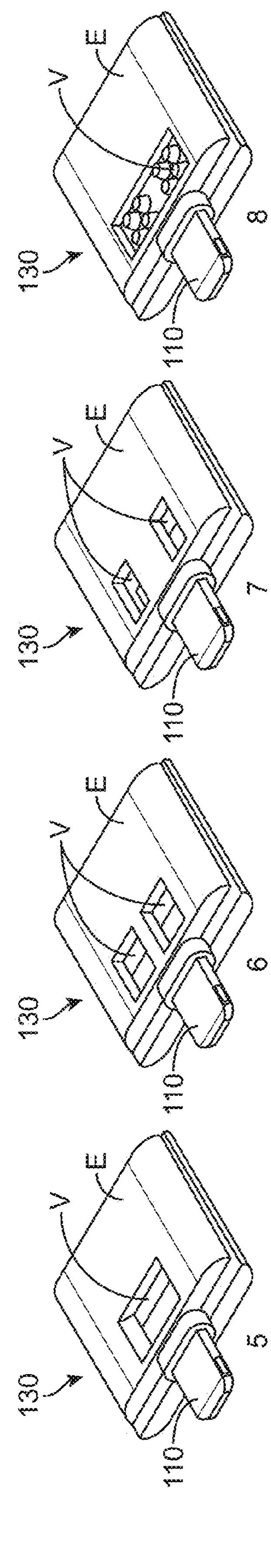



FIG. 19

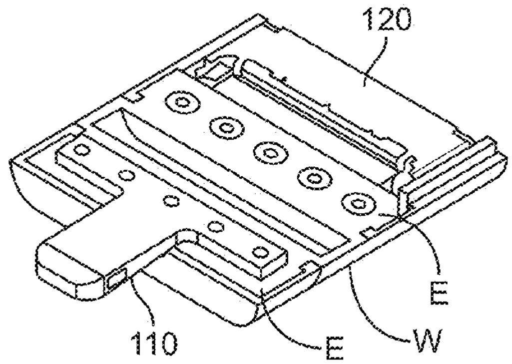



FIG. 20A

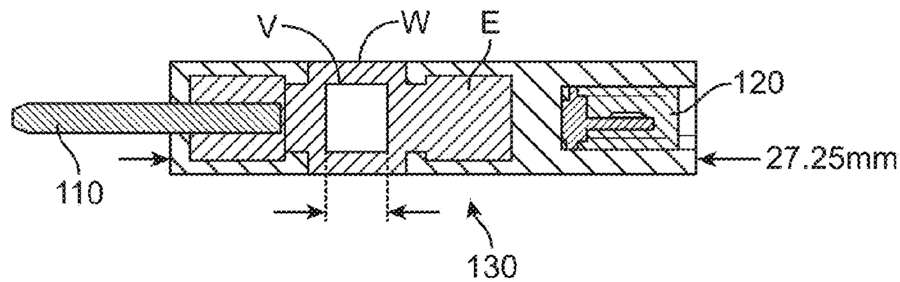



FIG. 20B

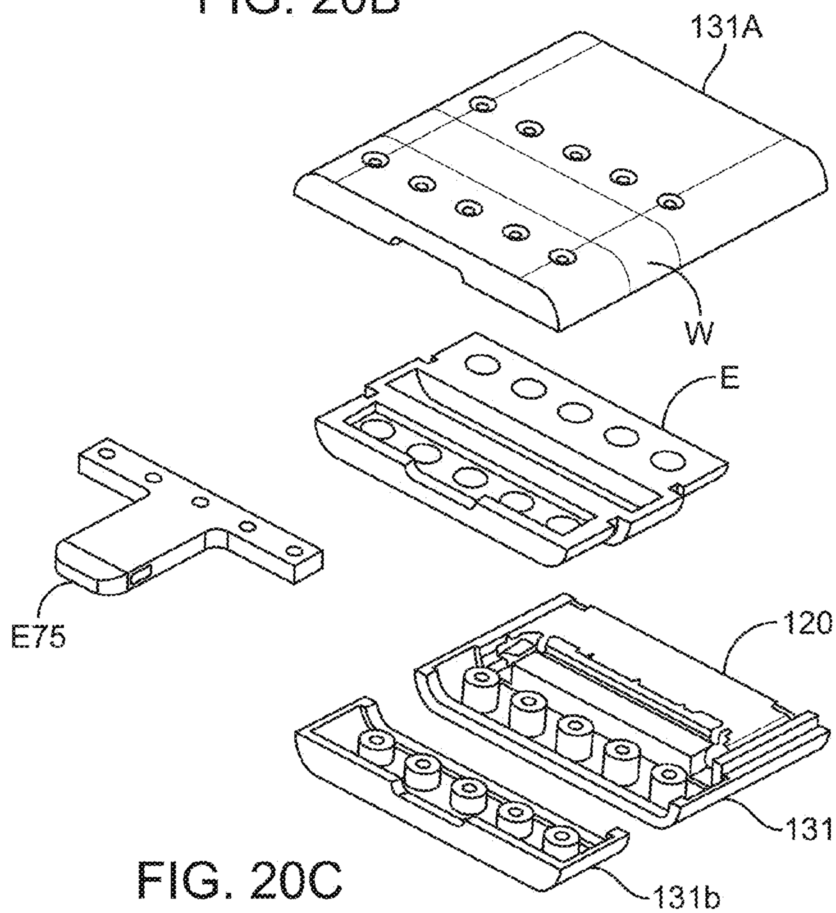



FIG. 20C

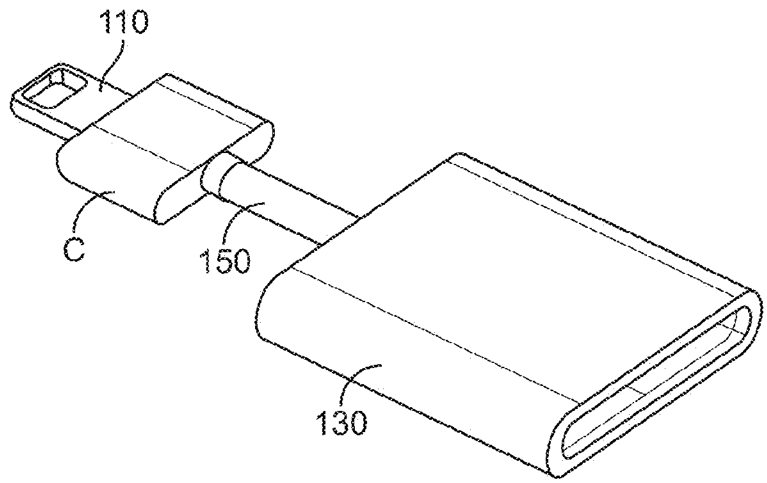



FIG. 21A

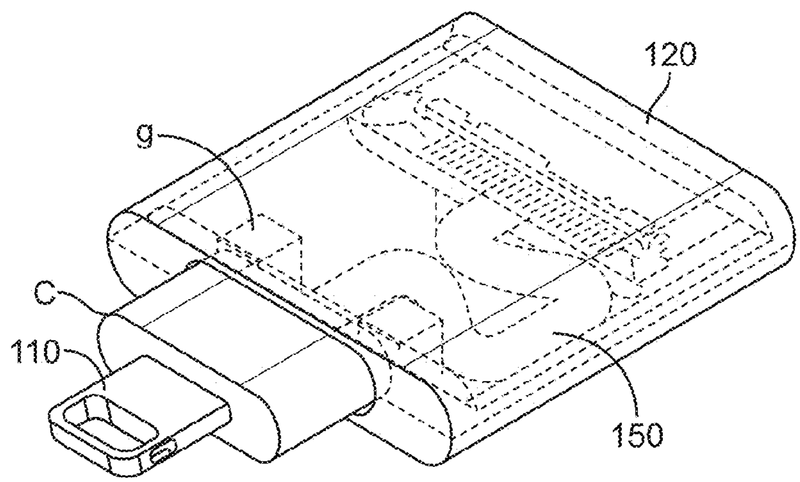



FIG. 21B

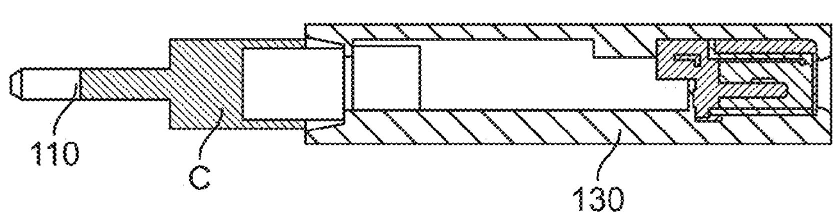



FIG. 21C

# COMPLIANT MOUNT FOR CONNECTOR

## BACKGROUND

The handheld consumer electronics market is replete with various portable electronic devices, such as cellular phones, personal digital assistants (PDAs), video games, and portable media players. Such portable electronic devices generally include a connector for connecting and mounting the devices to another electronic device, such as a docking station, a printer, sound system, a desktop computer, and the like. As new handheld devices are developed however, such devices may utilize differing types of connectors than used in other electronics devices, such that some devices may not readily connect to or be compatible with existing electronic devices. Thus, there is a continuing need for improved features and interconnection approaches that allows newer generation portable electronic devices to be used with older generation electronic devices.

## SUMMARY

The present invention relates generally to compliant mounts for use with connectors of portable electronic devices and other electronic devices, and in particular compliant mounts for use with connector adapters that allow a portable electronic device to be supportably mounted to another electronic device through the adapter. In one aspect, the invention provides a compliant mount for a connector adapter that allows a portable device having a first type of connector to be connected to and supportably mounted to another electronic having a second type of connector, the first type of connector differing from the second type of connector. In another aspect, the compliant mount supports a connector in a portable or other electronic device so as to allow compliant movement of the connector relative to the device. In some embodiments, the compliant mount provides controlled bending and torsional compliance in response to movement of the portable device while mounted to another electronic device with the adapter. In another aspect, the compliant mount provides sufficient flexibility to accommodate movement in response to bending and torsional forces applied through the first connector, while providing sufficient rigidity to support the portable device when connected to the other electronic device using the adapter.

In one embodiment, the invention comprises a first end connector electrically coupled with a second end connector, the first and second end connectors coupled by a compliant mount. The mount may include one or more elastomers tuned to accommodate bending and torsional movement of the compliant mount in response to movement of the portable device when connected to another electronic device using the connector adapter. The mount may include a front elastomer nearest the first connector and an inner elastomer disposed between the front elastomer and the second end connector, the front elastomer having a hardness greater than that of the inner elastomer so as to control the location of the compliant movement in the compliant mount. In some embodiments, the first end connector includes an insertable tab portion extending distally to a plurality of electrical contacts disposed thereon for insertion into a connector receptacle of the portable electronic device, while the second end connector includes a connector receptacle for receiving an insertable tab of a connector of the other electronic device.

In some embodiments, the first end connector includes a winged-portion at a base portion of the first end connector, the winged-portion having an ellipsoid shape that extends laterally outward from an insertion axis along which the insertable tab is inserted into the portable device. The front elastomer may be configured to substantially circumscribe a base portion of the insertable tab distal of the winged-portion and abut against a distal-facing surface of the winged-portion, while the inner elastomer may be configured to circumscribe the winged-portion at the base of the first end connector proximal of the front elastomer along the insertion axis of the first end connector. The location at which the compliant movement occurs may be controlled by selecting elastomers having a particular hardness, or by selection of a ratio of hardness between the elastomers. In some embodiments, the front elastomer is of sufficient hardness to move a pivot point at which compliant movement occurs in response to bending forces proximal of the front elastomer at or near the inner elastomer.

In another aspect, the compliant mount may include various other components to guide or control the compliant movement of the mount in response to torsional or bending forces applied to the connector adapter, such components may include: elastomers, springs, rigid members or housings, spherical members, torsion bars, or removable dongles, as described in further detail herein. Any or all of the features of the embodiments described herein may be used or combined in various ways to provide controlled compliant movement so as to accommodate bending and/or torsional forces resulting from use of the device.

In one aspect, the compliance mount coupling the first and second end connector may include one or more elastomers selected to accommodate a range of bending and/or torsional movement in response to forces applied to either the first or second end connector. The one or more elastomers may be selected so as to control the amount of bending or torsional forces allowed while maintaining the integrity of the electrical connection and mounting support provided by the adapter. The elastomers may be configured in any size or shape suitable for incorporated into the compliant mount and may comprise a silicone, polyethylene, or any elastomeric material having the desired flexure and rigidity. The elastomers may be pre-fabricated and mechanically fastened to the components of the connector adapter, may be overmolded over various assembled components within the connector adapter, or may include a combination of overmolded and pre-fabricated elastomer components. This use of elastomers may be incorporated within any of the connector adapter embodiments described herein.

In some embodiments, the range of compliance may be controlled by selecting one or more elastomers selected having a particular shore hardness, such as a shore hardness within a range of shore 27D and 72D. In addition, the compliance movement may be further tuned by selecting two or more elastomers having differing shore hardness, such that combining the differing elastomers controls a location of where the compliant movement occurs within the connector adapter. In some embodiments, elastomers having differing hardness values are selected from a group of hardness values including shore hardness values of 27D, 41D, and 72D. Furthermore, the one or more elastomers may also be configured, such as by shape, thickness or position, so as to direct and control the movement of the compliant adapter in response to the bending and/or torsional forces.

In one aspect, the compliant mount of a connector adapter includes a front elastomer near a base of the insertable tab of the first end connector and an inner elastomer between the front elastomer and the second end connector. In some embodiments, the front elastomer is selected to have a hardness greater than that of the inner elastomer so as to move a pivot point about which compliant movement occurs proximal of the first end connector along the longitudinal axis. Alternatively, using an elastomer of increased hardness level nearest the second end connector would move the compliant movement away from the second end connector. For example, the front elastomer may be selected to have a hardness between 5% and 100% greater than the inner elastomer, such as 10% to 75%, or 10 to 50% greater. In some embodiments, the compliant mount may include three or more elastomers of varying hardness levels so as to provide multiple pivot points according to differing levels of bending or torsional forces, the elastomer having increased hardness providing the secondary pivot points in response to increased levels of force. In addition, rigid members or plates attached to one or more elastomers may be used to limit the amount of compliant movement experienced within a particular elastomer so as to transfer compliant movement associated with increased levels of force into another elastomeric portion having increased hardness, thereby inhibiting overextension of any of the components. Alternatively, using an elastomer of increased hardness level nearest the second end connector would move the compliant movement away from the second end connector.

The use and advantages of using particular combinations of elastomers of differing hardness levels varies according to the desired application. Elastomers having increased hardness levels may provide greater resistance to bending or torsional stresses, while elastomers having lower hardness levels offer advantages during processes due to lower flow temperatures and reduced viscosity. Elastomers of various hardness levels may be selected according to the desired range of forces the adapter is expected to withstand without damage to the integrity of the adapter, whether cosmetic or functional.

These and other aspects and advantages of the invention will become apparent from the following detailed description and accompanying drawings which illustrate, by way of example, the principles of the invention. Various embodiments of the present invention may incorporate one or more of these and various other features described herein. A better understanding of the nature and advantages of the present invention may be gained by reference to the following detailed description and the accompanying figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A shows a portable electronic device having a first connector type including a connector receptacle corresponding to an insertable connector tab of a corded connector.

FIG. **1**B shows another portable electronic device having a differently size and type of connector and a corresponding connector tab in each of a corded connector and connector of a docking station.

FIG. **1**C shows the portable device of FIG. **1**B mounted in the docking station, the insertable connector tab of the docking station matingly received within the connector receptacle of the portable device.

FIG. **2**A shows an example compliant mount connector adapter that allows the portable device of FIG. **1**A to be mountably connected in the docking station of FIG. **1**B.

FIG. **2**B shows the portable electronic device of FIG. **1**A mounted in the docking station using the compliant adapter.

FIG. **2**C depicts bending on the adapter by out-of-plane movement of the portable device when mounted in the docking station.

FIG. **2**D depicts torsional forces applied on the adapter by rotational or twisting movement of the portable device when mounted in the docking station.

FIG. **3**A-**3**E shows example compliant adapters and corresponding components for use with such example compliant adapters.

FIG. **4**A shows an exploded view of a compliant mount connector adapter.

FIGS. **4**B-**4**D show steps of assembly of the compliant adapter of FIG. **4**A.

FIGS. **5**A-**10**B show alternative designs of compliant mount connector adapters.

FIGS. **11**A-**11**B illustrate views of differing types of construction of the first end connector of the adapter that provide compliance to the adapter.

FIGS. **12**A-**12**C show views of an example compliant mount connector adapter utilizing a spring/clutch type compliant mount.

FIGS. **13**A-**13**B show views of an example compliant mount connector adapter utilizing a torsion bar.

FIGS. **14**A-**14**B show views of an example compliant mount connector adapter utilizing a torsion bar and spring plungers.

FIGS. **15**A-**15**B show views of an example compliant mount connector adapter utilizing a spherical pivot.

FIGS. **16**A-**16**B show views of an example compliant mount connector adapter utilizing a ball and socket.

FIGS. **17**A**1**-**17**C**2** show views of an example compliant mount connector adapter utilizing a torsion spring.

FIGS. **18**-**19** show example compliant mount connector adapter utilizing an elastomer.

FIGS. **20**A-**20**C show views of an example compliant mount connector adapter utilizing an elastomer with a waist portion.

FIGS. **21**A-**21**C show views of an example compliant mount connector adapter utilizing a stowable dongle.

## DETAILED DESCRIPTION

Embodiments of the present invention generally relate to connector adapters that that provide an electronic connection and a compliant mount between two electronic devices. In particular, the invention includes a connector adapter having a first end connector and second end connector coupled with a compliant mount configured to accommodate bending and torsional movement in response to forces applied through the first or second end connectors.

In one aspect, the first end connector is of a different size or type than the second connector so that a portable device having a first type of connector can be connected and mounted to another electronic device having a second type of connector. In some embodiments, the first end connector is of a reduced size or dimension as compared to the second end connector such that the compliant mount is configured to distribute bending and/or torsional forces applied through the first connector to provide for an improved mounting and compliance between a device having a first type of connector type to a device having a second type of connector. The compliant mount may include one or more elastomers having a particular hardness to provide sufficient flexibility to accommodate a range of bending or torsional compliance while providing sufficient rigidity to maintain the electronic connection and to supportably mount the portable device with the other electronic device. These concepts can be further understood by referring to the following figures and accompanying descriptions.

FIG. **1**A is an illustration of a portable electronic device **200**, such as a media player, cell phone, imaging device, game player or media storage device, that may be used with a compliant connector adapter as described above. Such portable electronic devices **200** generally include a connector **210** to facilitate power supply charging and/or communication with another electronic device, such as a docking station, printer, sound system, or computer. The connector may include a connector receptacle **210** of the portable electronic device **200** that is configured to matingly engage with a corresponding connector tab **40** of connector plug **110** such that the electrical contacts **12** on connector tab **40** engage corresponding electrical contacts within the receptacle **210** when the connectors are mated. Many such devices include a corresponding insertable tab on a connector plug **110** attached to a cable **400** to facilitate connection of the portable electronic device **200** with a variety of differing devices.

In many applications, however, a corresponding insertable connector tab is incorporated into another electronic device **300**, such as a docking station, printer, sound system, or computer and the like, so that the portable electronic device can be connected directly to the other electronic device without the need for a cable connector therebetween, such as shown in FIG. **1**C. Often a docking station of the other electronic device includes a docking well **302** from which the insertable tab of the connector protrudes, such that when the insertable tab **320** is mated within the corresponding connector receptacle **210'** of the portable device, the portable device **200'** is electrically coupled with the other electronic device and the portable device may be supported in a mounted position, as shown in FIG. **1**C. Typically, the mounted position is within a pre-determined mounted plane Pm in which the device is in a substantially upright position to enable a user to view a display or manually operate a touchscreen of the device when connected. Although various devices include a docking well to assist in maintaining the portable device in a mounted, upright position, such docking wells may also limit the types and sizes of devices which can be docked or mounted to the other electronic device.

Since portable devices and electronic devices (e.g. docking stations), however, may use various differing types of connectors (e.g. 30-pin, 8-pin, USB, etc.) such that portable devices having differing types of connectors may not be suitable for direct connection or mounting between connectors of such devices. For example, the portable device in FIG. **1**A uses a connector of a first type having a reduced size and width (e.g. an 8-pin connector) while the portable device **200'** shown in FIG. **1**B uses a wider connector (e.g. a 30-pin connector), such that the portable device **200** having a first type of connector **210** cannot readily be connected and mounted to an electronic device **300** having a second type of connector **320**.

Although a direct adapter could conceivably be used, the increased moment arm created by the adapter as well as the change in dimensions between the differing types of connector may create undesirable increased in bending and torsional forces due in part to the change in mounting position, the weight of the portable device and forces inflicted by a user on the portable device. These increased forces may prevent a reliable connection between devices and interfere with the ability to mount the portable device with another device where connection types differ. While the devices could conceivably be connected using a corded adapter connector, using a cable connection to facilitate connection between two such devices may not provide the mounting support for which many electronic devices (e.g. docking stations) are designed. As the size and type of connector of a given portable device may change as new generations of portable devices are developed, it would be advantageous to provide a connector adapter to allow connection between a portable device having a first type of connector and another electronic device having a second type of connector. It would be further useful if such an adapter included a compliant mount to accommodate the increased bending and torsional forces that may result from use of such an adapter and to provide improved mounting support for the portable device. It would further advantageous if the adapter were configured to allow different sizes of portable devices to be connected to and mounted in an electronic device **300**, even portable devices that would otherwise be too large or unsuitable for mounting directly within the other electronic device.

FIG. **2**A shows a compliant connector adapter **100** in accordance with embodiments of the present invention that allow a portable electronic device **200** having a first type of connector to be connected to and mounted in another electronic device having a second type of adapter. The connector adapter includes a first end connector **110** of a first type and a second end connector **120** of the second type, the first end connector **110** being adapted for insertion into the connector **210** of the portable electronic device **200** and the second end connector **120** being adapted for matingly receiving connector **320** of the other electronic device **300**. The first end connector **110** and the second end connector are electronically coupled through the adapter body and structurally coupled by a compliant mount that provides sufficient rigidity to support the portable device **200** in a mounted position as shown in FIG. **2**B, while still allowing compliant movement or flexure in response to movement of the portable device **200** relative the other electronic device **300**. In addition, the compliant mount may be configured or tuned to accommodate a pre-determined range of movement above which the compliant mount provides resistance to inhibit further movement beyond the pre-determined range of movement. For example, the adapter body with compliant mount may be configured to resist application of one or both of a bending forces and a torsional force due to relative movement between the portable device **200** and the other electronic device **300**. These aspects allow flexibility to withstand application of forces that may be commonly encountered during use of the mounted portable device, while inhibiting movement that could potentially damage certain components of the connectors or electronic devices.

In many instances, the portable electronic device **200** is a handheld portable device that is sized for placement into a pocket of the user. By being pocket sized, the user does not have to directly carry the device and therefore the device can be taken almost anywhere the user travels (e.g., the user is not limited by carrying a large, bulky and often heavy device, as in a laptop or notebook computer). Often a user may wish to connect and mount the portable device to another device to facilitate charging of the power supply of the device or communication with the device to upload or download data from the device. For example, in the case of a portable music player device, the user may wish to mount and connect the device, such as an IPod, to a sound system, many such sound systems including a docking well with a protruding connector. When connected with the protruding connector, the portable music player is typically supported by the protruding connector in the upright position described above. Many such portable devices are pocket sized having a width of about 2-4 inches, a height of about 4-6 inches and depths ranging from about 0.5 to 1 inch, and the docking wells are designed accordingly. Although the docking wells assist in maintaining the portable device in a mounted, upright position, such docking wells may also limit the types and sizes of devices which can be docked or mounted to the other electronic device. In some embodiments, the connector adapters may be sized and adapted to extend above the bottom surface of a docking well so as to allow connection and mounting of portable devices that would not otherwise fit within the docking well. For example, an iPad or other such device larger than a typical handheld portable device may be mounted in a docking station having a docking well sized to receive typical handheld portable devices. For example, as indicated in FIG. **2**B, a connector adapter having a height (h) about the same or greater than a depth (d) of the docking well, allows a relatively large portable device **200"** (shown in dashed line) to be connected to the electronic device **300**; however, when connecting relatively large portable devices, an additional prop or support may be needed to fully support the devices, which in some embodiments may be incorporated into the adapter body.

Despite the above noted advantages of the connector adapter, there are additional challenges associated with use of a connector adapter to connect and mount a portable device to another electronic device. Since the connector adapter extends a distance away from the connector of the other electronic device, the resulting increased moment arm and decreased dimensions of the first end connector considerably increase the stresses and forces experienced by the first end connector, which can be more difficult to counter given the decreased dimensions of the first end connector. The compliant connector adapter described herein addresses these challenges by utilizing various designs and configurations of compliant mounts that allow the connector adapter to provide a range of compliant movement in response to these forces while maintaining the electronic connection between the devices and the mounting support of the portable device.

FIGS. **2**C and **2**D illustrate some of the bending and torsional forces that may be experienced by the compliant mount connector adapter **100** during typical use of the device. In FIG. **2**C, a user may inadvertently or purposefully move the portable device **200** away from the mounted plane Pm in which the portable extends when supportably mounted in a non-displaced position. The compliant mount coupling the first and second end connectors in the connector adapter may be configured to withstand a range of bending movements as desired that result from out-of-plane movement of the portable device. This out-of-plane movement of the portable device and first end connector may be expressed as an angular displacement, θb, measured from the non-displaced mounted plane Pm, the pivot point of such movement occurring within the compliant adapter. The location of the pivot point may be adjusted or controlled by material selection of the compliant mount components or by the dimensions and configuration of the compliant mount components within the connector adapter. In some embodiments, the compliant mount is configured to withstand bending movement associated with θb within a range of between +/0° and +/−90° (e.g. +/5° and +/−80°) before sustaining damage, cosmetic or structural. The compliant mount may also be configured so as to pop-off or release from the connector of the other electronic device at a certain θb, so as to prevent damage of either connector or the adapter itself. The first or second connector may release merely due to the stiffness of the compliant mount or may include a mechanism by which a retention mechanism coupling either the first or second connector to the corresponding connectors of the devices effects release of the connector at the desired displacement, such as at an θb of about 60°.

As shown in FIG. **2**D, movement of the portable device **200** may also include rotation of the portable device at an angular displacement θt away from the mounted plane Pm. Similar to the bending displacement described above, the compliant mount components within the connector adapter may be configured to withstand and/or respond to a range of angular displacements, θt, before sustaining any damage, whether cosmetic or structural, or before releasing the adapter at either connector. As can be understood with reference to FIG. **2**D, the pivotal axis about which the portable device rotates extends through the connector adapter. The location of this axis as well as the level of compliance and resistance can be controlled by material selection as well as the dimensions and configuration of the compliant mount components. In some embodiments, the compliant mount is configured to withstand bending movement associated with θt within a range of between +/0° and +/−90° (e.g. +/5° and +/−40° before sustaining damage, cosmetic or structural. The compliant mount may also be configured so as to pop-off or release from the connector of the other electronic device at a certain θt, so as to prevent damage of either connector or the adapter itself. The first or second connectors may release merely from the stiffness of the compliant mount or by a mechanism which releases a retention mechanism coupling either the first or second connector to the corresponding connectors of the devices to effect release of the adapter from either connector at the desired rotational displacement, such as at an θt of about 60°.

FIG. **3**A shows three different embodiments of example compliant mount connector adapters in accordance with the invention, each having a differing shape (shapes A, B and C), each shape compatible with certain constructions and variations, as will be described in further detail. Each compliant mount connector adapter **100** includes a first end connector **110** electrically connected to a second end connector **120** (not visible) by a compliant electrical coupling (not visible) that can accommodate the compliance provided by the compliant mount. In the embodiments shown, the first end connector **110** is of a different type than the second end connector **120**, such that the first end connector **110** has fewer electrical contacts and a reduced overall size as compared to the second end connector **120**. Although in the embodiments described herein, the first end connector **110** is reduced in size as compared to the second end connector, it is understood that the first end connector may be larger than the second end connector or that the connectors may be of the same type or size and still allow for many of the advantages of the connector adapter described herein.

FIG. **3**B illustrates an exploded view of an example compliant mount connector adapter **100**, the component shown separated along the device's longitudinal axis. In this embodiment, the first end connector **110** is of a connector type of reduced size and having eight electrical contacts dispose thereon, while the second end connector **120** is an elongated 30-pin receptacle. The first end connector **110** and second end connector **120** are connected by a compliant connection through a printed circuit board component **115**, configured to allow communication between the differing types of end connectors. Once connected, the components are covered by an adapter body housing **112** that that may include an end collar **111** to secure the adapter components together. Although in this embodiment, the housing **112** is shown as a shell, it is appreciated that in some embodiments the adapter may or may not include a housing and various other components may be included therein.

FIGS. **3**C-D illustrate an example connector tab **40** of the first end connector **110** of the connector adapter **100** of FIGS. **3**A-**3**B. FIG. **3**C depicts the insertable tab **40** of the male connector plug **110**. Connector plug **10** includes a first connector body **42** and the tab portion **40** that extends longitudinally away from a proximal printed circuit board component **42** along a longitudinal axis of the connector **110**. In this embodiment, the first connector plug **110** is coupled to the second connector receptacle (not shown). As shown, body **42** includes a printed circuit board **104** that extends into ground ring **105** towards the distal tip of connector **110**. One or more integrated circuits (ICs), such as Application Specific Integrated Circuit (ASIC) chips **108***a* and **108***b*, can be operatively coupled to printed circuit board **104** to provide information regarding connector **110** to perform specific functions, such as authentication, identification, contact configuration and current or power regulation.

In the above embodiment, tab **40** is sized to be inserted into a corresponding connector receptacle **210** of an electronic device during a mating event and includes a contact region **46** formed on a first major surface **40***a* extending from a distal tip of the tab to a winged-portion **109** such that when tab **40** is inserted into the connector receptacle **210**, the winged-portion **109** (or an elastomer disposed thereon) abuts against a housing of the portable electronic device surrounding the connector receptacle. In one particular embodiment, insertable tab **40** is 6.6 mm wide, 1.5 mm thick and has an insertion depth (the distance from the tip of tab **40** to winged-portion **109**) of 7.9 mm. Tab **40** may be made from a variety of materials including metal, dielectric or a combination thereof. For example, tab **40** may be a ceramic base that has contacts printed directly on its outer surfaces or may include a frame made from an elastomeric material that includes flex circuits attached to the frame. In some embodiments, tab **40** includes an exterior frame made primarily or exclusively from a metal, such as stainless steel, with a contact region **46** are formed within an opening of the frame. Typically, the structure and shape of tab **40** is defined by a ground ring **105** and can be made from stainless steel or another hard conductive material, although the construction of the tab **40** may be varied, such as through the use of flexible conductive materials or conductive elastomers, to provide additional compliance as desired.

In some embodiments, the winged-portion **109** may be fabricated to extend laterally outward in each direction substantially perpendicular to the longitudinal axis of the connector adapter, shown in FIG. **3**C as an oval or ellipsoid shape with pointed ends that extends around the base of the first end connector **110**. This winged-portion **109** may be formed integrally with the ground ring **105**, or may be coupled to the ground ring such as by a weld or other suitable mechanical coupling. By extending laterally outward, the winged-portion **109** transfers forces applied through the insertable tab outward so as to allow an increased area by which the compliant mount can accommodate and/or counter the applied forces. For example, the winged portion **109** may distribute forced applied through a first end connector **110** having a reduced width over an increased width to distribute the applied forces more evenly to the second connector having a greater width, thereby taking advantage of any compliance or flexibility associated with second connector tab of the other electronic device. To provide this distribution of force, the winged-portion **109** may be fabricated to be substantially rigid, although in other embodiments, the winged-portion **109** may be configured accordingly to include varying levels of flexure or compliance.

In this embodiment, contact region **46** is centered between the opposing side surfaces **40***c* and **40***d*, and a plurality of external contacts are shown formed on the top outer surface of tab **40** within the contact region. The contacts can be raised, recessed or flush with the external surface of tab **40** and positioned within the contact region such that when tab **40** is inserted into a corresponding connector receptacle they can be electrically coupled to corresponding contacts in the connector receptacle. The contacts can be made from copper, nickel, brass, stainless steel, a metal alloy or any other appropriate conductive material or combination of conductive materials. In some embodiments contacts can be printed on surfaces **40***a* using techniques similar to those used to print contacts on printed circuit boards. In some other embodiments the contacts can be stamped from a lead frame, positioned within regions **46** and surrounded by dielectric material.

In an exemplary embodiment, the connector tab **40** may also include one or more retention features **14** corresponding to one or more retention features within the receptacle **20**. For example, the retention features of the tab **40** may include one or more indentations, recesses, or notches **14** on each side of tab **40** that engage with corresponding retention feature(s) **24** within the receptacle, the corresponding retention feature(s) **24** extending or protruding toward the insertion axis along which the connector tab **40** is inserted so as to be resiliently received within the indentation, notch or recess within the sides of tab **40**. In one particular embodiment, retention features **14** are formed as curved pockets or recesses in each of opposing side surfaces **40***c*, **40***d*, the shape and location of the retention features **14** corresponding to complementary retention features **24** in the receptacle when in a mated configuration. Generally, the retention features **24** of the receptacle resemble spring-like arms configured to be resiliently received within the recesses **14** once the connector plug **10** and receptacle **20** are properly aligned and mated. The engagement of these resilient retention features of the receptacle and the retention feature within the tab can be seen in more detail in FIG. **3**C.

In some embodiments, one or more ground contacts can be formed on tab **40**, or may include on an outer portion of tab **40**. In many embodiments, the one or more ground contacts are formed within and/or as part of a pocket, indentation, notch or similar recessed region **14** formed on each of the side surfaces **40***c*, **40***d* (not shown in FIG. **3***a*), such that the retention feature **14** may also act as the electrical ground for tab **40**.

FIG. **3**D depicts a connector receptacle **20** in accordance with many embodiments. The connector receptacle **20** also includes side retention mechanisms **24** that engage with corresponding retention features **14** on connector plug **10** to secure connector plug **10** within cavity **147** once the connectors are mated. In many embodiments, the retention mechanisms **24** are resilient members or springs, often formed from an elongated arm that extends from a rear portion of the receptacle and extends toward the opening of cavity **147**, such as shown in more detail in FIG. **3**C. The retention mechanisms **24** may be made from an electrically conductive material, such as stainless steel, so that the feature can also function as a ground contact. The connector receptacle **20** may also include two contacts **28**(**1**) and **28**(**2**) that are positioned slightly behind the row of signal contacts and can be used to detect when connector plug **10** is inserted within cavity **147** and/or when connector plug **10** exits the cavity **147**. When tab **40** of connector plug **10** is fully inserted within cavity **147** of connector receptacle **20** during mating between the plug and connector receptacles, each of contacts **12**(**1**) . . . **12**(**8**) from one of contact region **46** are physically coupled to one of contacts **22**(**1**) . . . **22**(**8**).

FIG. **3**E depicts assembly of an example first end connector for use with a compliant mount connector adapter. The hollow ground ring **105** of the connector is fabricated from stainless steel, a distal portion of the ground ring defining a cavity for assembly of the plurality of electrical contacts on a printed circuit board **104** inserted from a distal rear portion of the ground ring **105**. A distal portion of the ground ring is fabricated to include a winged-portion **109** resembling an ellipsoid shape with pointed ends that extends laterally outward from the base of the insertable tab **44**. A distal portion of the printed circuit board includes a plurality of pad for bonding to a plurality of electrical contacts **12** placed in contacts with the pads, after which an overmold is applied to secure the electrical contacts **12** in place and provide a flush contact surface by which the insertable tab interfaces with the connector receptacle of the portable device **200**.

FIG. **4**A depicts an exploded view of an example compliant mount connector adapter **100**. The embodiment in FIG. **4**A uses elastomers to provide bending and torsional compliant movement. As described above, one or more elastomers of differing hardness may be used to provide increased control of compliant movement within the connector adapter. The compliant mount includes a front elastomer, Ef, that slides over the insertable tab **40** and abuts against the winged-portion **109** of the ground ring **105** and an inner elastomer, Ei, that slides over the winged-portion **109** of the ground ring. By selecting an front elastomer Ef having a hardness greater than the inner elastomer Ef, the compliant movement of the elastomers is moved predominately to the inner elastomer, Ei, such that the pivot point about which compliant movement occurs in response to bending forces occurs proximal of the front elastomer. The front elastomer may be configured to extend laterally outward so as to abut against a front facing or distal facing surface of winged portion **109**, while the inner elastomer, Ei, is configured to fittingly receive the winged-portion **109**. The front elastomer may be selected to have a hardness between 5% and 100% greater than the inner elastomer, such as 10% to 75%, or 10 to 50% greater than the inner elastomer, Ei, so as to move the pivot point about which the compliant mount bends to the more flexible elastomer, which is the elastomer having the lower hardness level.

In another aspect, the compliant mount connector adapter includes an electromagnetic interference shield surrounding the printed circuit board components of each of the first and second end connectors. As shown in the embodiment of FIG. **4**A, the shield may comprise a slide-on shield, such as shield **192** configured to slide over the second end connector receptacle **120**, or the shield may comprise a thin metallic layers adhesively applied to one or more elastomers, such as shield **190** which comprises a piece of copper tape adhesively applied to the inner elastomer Ei so as to shield the printed circuit board of the first end connector. The use of metallic tape, such as in shield **190** is advantageous as it allows for increased flexibility where compliant movement occurs within the connector adapter. The assembly of such a shield is described further in FIGS. **4**B-**4**C.

The compliant mount connector adapter may also include one or more shims, such as shims **133** disposed on opposing sides of the shield **192** in FIG. **4**A. The one or more shims may be configured to provide additional support and/or rigidity within the adapter body housing **131** as the compliant mount flexes in response to bending and/or torsional stresses. The shims may be used to prevent spaces or gaps between the housing and the internal components during flexure so as to inhibit cosmetic or structural damage to the connector adapter housing **131**.

FIGS. **4**B-**4**D illustrate assembly of the shield **190** to the elastomeric components surrounding first end connector **110**. Once the first end connector and second end connector are assembled, as shown in FIG. **4**B, the inner elastomer, Ei circumscribing the winged-portion **109**, and the front elastomer, Ef, abutted against the front facing surface of winged-portion **109**, a piece of copper tape **190**, as shown in FIG. **4**B can be applied as shield about the first end connector **110**. The copper tape **190** may include a perforated or scored opening **191** in the center through which the insertable tab **40** of first end connector **110** can be inserted, as shown in FIG. **4**C, the adhesive side of the copper table adhering to the front elastomer, Ef. The copper tape is then folded over the sides of the inner elastomer, Ei, as shown in FIG. **4**D, thereby adhering the copper tape to the inner elastomer to form shield **190**. These aspects relating to shield may be incorporated into any of the embodiments described herein and may include any suitable metallic material suitable for use as an electromagnetic shield.

In another aspect, additional elastomeric components, such as a conductive elastomer within the coupling between the first and second end connectors, shown as Ec in the embodiment of FIG. **4**A. This feature may provide additional flexibility and compliance within the electrical connections and/or grounding pathway and may be used in any of the embodiments described herein.

FIG. **5**A-**10**B illustrated various different embodiments of the compliant mount connector adapter, in accordance with the invention. As can be understood with reference to the figures, the electrical coupling between the first end connector and second end connector may be incorporated into the compliant mount or may extend through the compliant mount. For example, in some embodiments the first end connector and second end connector may be electrically connected through a flexible printed circuit board which may be incorporated into one or more of the compliant mount features described herein, while in other embodiments the first end connector and second end connector may be electrically connected by wires that extend through any of the compliant mounts described herein. It is appreciated that various features described in any of these embodiments may be combined with various other features disclosed herein or may further include various other features known to one of skill in the art not specifically recited herein.

FIGS. **5**A-**5**E depict compliant mount mechanisms that utilize springs or mechanical connections to guide and/or resist movement due to bending or torsional forces. FIG. **5**A depicts a compliant mount connector having a compliant mount **132** that includes a spring. The spring may be selected to resist any or all of an axial force, bending force and torsional force applied to the adapter through the first end connector. Utilizing springs fabricated from different materials, gages and length, the resistance of the spring can be controlled to fine tune the strength and rigidity of the adapter as well as the range of movement allowed by the spring. The compliant mount **132** may optionally include an elongate bar attached to the base of the first end connector **110** extending substantially perpendicular to the longitudinal axis of the adapter, as seen in FIG. **5**A. The elongate bar between the spring and the first end connector **110** may provide increased resistance to torsional forces and/or bending forces along the plane in which the elongate bar extends, the properties (size, material, modulus of elasticity) of the elongate bar as well as its position and configuration to determine the amount of resistance provided by the elongate bar. The combination of the spring and the elongate bar allows for varying degrees of resistance in response to increases in bending or torsional forces.

FIG. **5**B shows a connector adapter **100** having a compliant mount **132** comprising a torsion bar extending from the first end connector toward the second end connector. The torsion bar provides resistance to both bending and torsional forces applied through the first or second end connectors. The compliant mount **132** may optionally include an elongate bar for providing increased resistance to increased forces, such as the elongate bar in FIG. **5**A or a circular bar, such as shown in FIG. **5**B to allow increased bending in one or more planes.

FIG. **5**C shows a connector adapter **100** having a compliant mount **132** that includes two springs placed in parallel. Parallel springs may provide increased resistance to bending forces along one or more planes, as well as torsional forces. In addition, as two springs allow for greater distribution of forces, smaller springs or springs having reduced thickness or lower spring constants may be used to provide similar resistive forces as the single spring in FIG. **5**A. The first end connector may further include an elongate member, such as those in FIG. **5**A-**5**B, or may be attached to an relatively thin plate attached to the end of each of the parallel springs. Optionally, the first end connector may be connector through a full-sphere or half-sphere, such as shown in FIG. **5**C, so that engagement of the sphere within the cavity of the adapter body **130** guides rotational and bending movement of the first end connector within certain limits so as to control flexibility and compliance of the connectors within the adapter.

FIG. **5**D shows a connector adapter **100** having a compliant mount **132** that includes a friction ball and socket, the first end connector being attached to the sphere and the adapter body being attached to the socket, such that engagement between the sphere and socket guide the rotational and bending movement of the first end connector within the adapter body **130** while friction between the sphere and socket provide resistance to the torsional and bending forces. The amount of resistance provided can be controlled through the geometry, material selection, surface finishing and sizing of the ball and socket. For example, the ball and socket could be configured to allow movement in response to a relatively small amount of rotational/torsional force or bending force, but to provide increased resistance in response to increased levels of force. This may be accomplished by configuring the ball and socket so that once the first end connector is rotated or bent beyond a certain angle, further rotation of the ball and socket meets with increased resistance, such as by use of an oblong sphere.

FIG. **5**E shows a connector adapter **100** having a compliant mount of a connector adapter that includes an elongate tube extending laterally outward from a base portion of the first connector, the tube coupled with a helical spring to provide increase resistance to bending forces applied through the first connector.

FIGS. **6**A-**6**E depict compliant mounts of connector adapter that utilize elastomeric materials to resist movement due to bending or torsional forces. The internal components may be mechanically fastened to one or more elastomeric components, and the components may be formed of silicone, polyethylene, or various other elastomeric materials. The resistance provided by the elastomer may be controlled by selecting elastomers of certain hardness to provide a desired resistive force. In some embodiments, the resistance of a selected elastomer may be adjusted by including of one or more voids, such as shown in FIG. **6**A and FIG. **6**E, or by tapering the elastomer E in the area in which reduced stiffness is desired. By forming a void in a waist portion, such as shown in FIG. **6**E, the point at which compliant movement occurs within the adapter can be reliably controlled, thereby avoiding unintended movement of certain components to avoid damage to the first and second connectors or the adapter housing. While in one aspect, the elastomer may be overmolded over the internal components and encased within a rigid outer housing, in other embodiments, such as shown in FIGS. **6**D and **6**E, the elastomer may form a part of or the entire exterior of the connector adapter **100**.



FIG. **6**A shows a connector adapter **100** wherein the compliant mount comprises an inner elastomer within an exterior rigid shell.

FIGS. **7**A-**7**E depict connector adapter having compliant mounts that utilize elastomer components in addition to rigid materials to provide increased resistance movement due to bending or torsional forces. FIG. **7**A shows a connector adapter **100** wherein the compliant mount comprises a tapered rigid housing, while FIG. **7**B shows a connector adapter **100** wherein the compliant mount comprises a rigid housing having spaced apart rigid members that in parallel accommodate greater torsional movement while providing resistance to bending or torsional stresses.

FIGS. **8**A-**8**B depict compliant mount mechanisms that utilize bendable supporting wires to resist movement due to bending or torsional forces. The bendable support wires may be configured to deform elastically, plastically, or a combination of elastic and plastic deformation depending on the magnitude of force applied. FIG. **8**A shows a connector adapter **100** wherein the compliant mount comprises a bendable material having a plurality of bendable support wires extending therethrough. The wires may having a high elastic modulus to allow the adapter to be bent within a range of angular displacements in response to bending or torsional forces, or may be configured to have a high plastic modulus so that the adapter could be manually bent into a variety of configurations such that once released the adapter remains in the desired configuration. FIG. **8**B shows a similar connector adapter as in FIG. **8**A where the bendable wires are concentrated in a central portion extending along the longitudinal axis of the connector adapter so as to function similar to a torsion bar, while still providing the advantages of bendable wire supports described above.

FIG. **9** depicts a compliant mount mechanism that utilizes a stowable dongle to resist movement due to bending or torsional forces. This embodiment is described in more detail in FIGS. **21**A-**21**C.

FIGS. **10**A-**10**B depict a compliant mount connector adapter that include one or more internal spring members coupled with two front facing surfaces having detents or protrusion, the detents or protrusions engageable with a corresponding feature on the portable device so as to provide a longer moment arm to withstand bending or torsional forces applied to the adapter through movement of the first portable device, as described herein.

FIGS. **11**A-**11**B depict various designs (I, II and III) of the first connection by which the stiffness and flexibility of the first connector may be controlled. In design A, the stiffness and rigidity of the connector is controlled by adjusting the exterior mounting geometry of the base **109** of the insertable tab **40** of connector **110** (e.g. increasing the width or thickness of the base **109**. In design B, the stiffness and rigidity of the connector is controlled by adjusting the internal geometry by which ground ring interfaces with the internal PCB component. In design C, the stiffness and rigidity of the connector is controlled by adjusting the construction of the connector **110**, for example constructing the ground ring from layers having differing materials, such as a middle layer having reduced stiffness (darkened portion in cross-section D-D) sandwiched between outer layers of increased stiffness and rigidity.

FIGS. **12**A-**12**C depict a perspective view, cross-sectional view, and an exploded view of a compliant mount connector adapter having a spring/clutch design. The compliant mount connecting the first end connection **110** and second end connector **120** includes a compression spring (S) and detent cam **136** assembled within a rigid outer housing, top housing **131**A and bottom housing **131**B. The detent cam **136** comprises two component having interfacing undulating surfaces, one undulating surface included in a rear-facing base portion of the insertable tab and the other undulating surface included on a second component attached to the bottom housing **131**B. A compliant collar (C) may also be used to seat the base portion of the insertable tab **40** into the rigid outer body and may provide additional resistance to bending forces. The undulating portions of the cam surface may be configured so as to provide a desired level of resistance to rotation force, which once exceeded allows the first connector to rotate, while the spring may be used to provide resistance to bending forces.

FIGS. **13**A-**13**B depict a perspective view and an exploded view, respectively, of a compliant mount connector adapter having a torsion bar design. The adapter body **130** may include a top and bottom rigid housing **131**A, **131**B and an internal torsion bar (T) coupling the first and second connectors providing resistance to both bending and torsional forces. In addition, a compliant collar (C) may be used where the insertable tab **40** seats within the rigid outer body to provide additional resistance to bending forces. The collar (C) may also be used to move the pivot point away from the first connector by selecting a collar of a material of sufficient hardness or stiffness.

FIGS. **14**A-**14**B depict a perspective view and an exploded view, respectively, of a compliant mount connector adapter having a torsion bar design, similar to that in FIGS. **13**A-**13**B, that further includes spring plungers **138** engaged within spring plunger detents **138'** in each side of a base portion of the connector **110**. The spring plungers **138** extend laterally outward so as to provide increased resistance to torsional forces while allowing rotation of the spring plunger to accommodate movement of the first connector **110** associated with displacement from bending movement. The resistive force provided by this configuration is related to the spring force of the spring plungers as well as the dimensions of each.

FIGS. **15**A-**15**B depict a perspective view and an exploded view, respectively, of a compliant mount connector adapter having a spherical pivot. The base of the insertable tab **40** of connector **110** is attached to a spherical or semi-spherical component **140** that is in turn attached to a laterally extending plate **141** that distributes applied forces to a pair of springs attached underneath plate **141**. The laterally extending plate **141** distributes the forces along the length of the adapter to the pair of springs inhibit torsional and bending movement, while the spherical component **140** is interfaced within a spherical seating **140'** in the bottom rigid housing **131**B so as to guide movement of the first connector to control the point at which movement of the first connector **110** pivots.

FIGS. **16**A-**16**B depict a perspective view and an exploded view, respectively, of a compliant mount connector adapter having a ball and socket. The base of the insertable tab **40** of connector **110** is attached to a spherical component **140** that is seating against a frictional adjustment plate **142** having a spherical surface engaged against the spherical component and held in place by a front plate **141** through which the base portion of the connector **110** extends and attached to the spherical component **140**. The resistance of both the bending and torsional forces is provided primarily by the friction between the spherical component and the frictional adjustment plate.

FIGS. **17A1**-**17C2** depict various views of compliant mount connector adapter having one or more helical springs used to couple a rotatable tube **144** extending laterally at an end of the adapter body **130** near the first end connector **110**. In some embodiments, the tube is rotatably attached to a structure frame **146** using a helical spring S at each end of tube **144**, the structural frame insertable into a rigid housing of adapter body **130**. The tube **144** may be configured to rotate within a desired range of movement, such as 90 degrees or less in each direction from the upright position shown in FIG. **17**A-**1**, such as about 45 degrees in each direction. In some embodiments, a helical springwraps around each end of tube **144** and is coupled to the tube **144** near where the first end connector **110** extends from tube **144**, such as by a weld or rigid attachment, while the other end of the springs attach to the structural frame **146** at points **147**, as shown in the exploded view of FIG. **17**A-**2**. An end collar **121** may be used to secure the second end connector (not shown) within the adapter body **130** housing.

As shown in FIGS. **17**B**1**-**17**B-**4**, a compliant mount connector utilizing one or more helical springs as described above may provide six-degrees of freedom. The rotation of the tube **144** provide rotation along the X-axis, while gaps between each helical spring and the structural housing **146** and the rigid housing of the adapter body allow additional degrees of freedom to provide rotation along the Y and Z axes, as well as translation along the Y and Z axes. The amount of translation and rotation along each axis can be controlled by the spacing between the tube **144** and associated helical springs and the structural frame **145**, as well as by the material properties and dimensions of each spring (e.g. spring constant). In the embodiments shown, the tube **144** is configured so that its length, l, extends almost the entire width of the adapter body **130** so as to distribute forces applied to the adapter through the structural frame **145**. In some embodiments, the tube is a hollow tube fabricated of a rigid materials, such as stainless steel, and has a length of about 24.4 mm and a diameter of about 6.8 mm. Each helical spring may wrap around each end of the tube **144** and attach to the tube **144** near a central portion so as to allow for the additional movement and degrees of freedom described above. FIGS. **17**C-**1** and **17**C-**2** illustrate a perspective and cross-sectional view of an example tube having two helical springs attached at each end.

FIGS. **18**-**19** show various embodiments of compliant mount connector adapters that use an elastomer component within the adapter body **130** to provide resistance to bending and torsional forces. In some embodiments, the elastomer E substantially fills the entire cavity within a rigid shell of the adapter body **130**. A base portion of the connector **110** may be mechanically fastened to the elastomer, such as in designs **1**-**4** of FIG. **18**, and may be fastened by a bar that extends laterally outward, such as in designs **3** and **4**, so as to distribute torsional forces applied through the first connector. In other embodiments, the elastomer E may be overmolded over a portion of the first or second connector internal to the adapter body **130**, thereby obviating the need for additional mechanical fastening, such as shown in designs **5**-**8** of FIG. **19**. In addition, when overmolding the elastomer E, voids (v) may be included to provide for more consistent uniform injection of the overmold material or to adjust or vary the stiffness of the elastomer in certain portions. For example, including one or more voids in a portion of the elastomer would generally reduce the stiffness in that area, thereby varying the resistive force provided by the elastomer E and controlling the location of a pivot point about which compliant movement occurs.

FIGS. **20**A-**20**C depict various views of a compliant mount connector adapter having an elastomer portion with a waist portion in a mid-section of the elastomer. A mid-section of the elastomer includes a void, which reduces the resistance provided by the elastomer in the waist portion so that pivotal movement of the adapter in response to bending forces occurs at or near the waist portion, sufficiently away from the first connector, thereby avoiding damage to either the first end connector or second end connector. In addition, each of the top and bottom rigid housing components **131**A, **131**B may include two components attached to the elastomer on opposite sides of the waist portion so that the elastomer disposed at the waist portion forms the exterior surface of the compliant adapter. This configuration avoids cosmetic or structural damage to the rigid housing as the compliant movement in response to bending occurs primarily at the waist portion of the elastomer.

FIGS. **21**A-**21**C depict perspective views and a cross-sectional view of a compliant mount of a connector adapter that utilizes a dongle **150** or short cord that is stowable within the adapter body **130**. A base portion of the first connector releasably attached to a rigid housing of the adapter, such as in a friction or interference fit. Once the force provided by the friction fit is overcome, by bending or torsional force, the first connector releases yet remains electrically coupled and attached to the adapter through a short dongle **150** or short cord stored within an internal void in the adapter body **130**. The internal cavity of the adapter body **130** in which the dongle cord **150** is stored may further include one or more guide blocks (g) which may be positioned to assist in storage and movement of the dongle cord **150** when deployed. This feature prevents cosmetic or structural damage to the adapter while still allowing the portable device to remain electrically coupled to the other electronic device through the stowable dongle **150**. Once the dongle **150** is deployed a user can easily push the dongle **150** back into the void of the adapter body **130** and restore the friction fit of the first connector by manually inserting the collar C of first connector plug into the adapter body **130**, thereby allowing the adapter to function as a supporting mount for the portable device. This feature has an additional advantage in that the adapter can function as a short corded adapter in which mounting of the portable device is not required, particularly useful in connecting larger devices, and allowing the adapter to be used as a mounting adapter so that a portable device can be mounted onto the other electronic device.

While this invention has been described in terms of various embodiments, there are alterations, permutations, and equivalents, which fall within the scope of this invention. For example, although the invention has been described in terms of a portable electronic device, it should be appreciated that certain features of the invention may also be applied to various other types of connections between devices and mounting of various other components, in accordance with the spirit and scope of the invention. While the above is a complete description of various embodiments of the invention, it is appreciated that various alternatives, modifications, and equivalents may be used and any of the features described in different embodiments may be combined in accordance with the spirit and scope of the invention.

What is claimed is:

**1**. A compliant connector adapter for connecting a portable electronic device with an other electronic device, the adapter connector configured to enable data and power transmission between the electronic devices, the adapter connector comprising:

a first end connector and second end connector, the first end connector having a plurality of electrical contacts to enable data and power transmission therethrough and being configured to enable said data and power transmissions to pass between the portable electronic device and the second end connector, the first end connector further configured for removable mating engagement with the portable electronic device, and the second end connector having a plurality of electrical contacts arranged to enable data and power transmission therethrough and being configured to enable said data and power transmissions to pass between the other electronic device and the first end connector thereby enabling said data and power transmissions to pass between portable electronic device and the other electronic device, the second end connector further configured for removable mating engagement with the other electronic device, and

a compliant mount body coupling the first end connector and second end connector so as to support the first end connector when the second end connector is matingly engaged with the other electronic device, wherein the compliant mount body comprises one or more springs or torsion bars configured to resist bending or torsional force applied through the first or second end connector and the compliant mount body is sufficiently flexible to allow relative movement of the first end connector relative to the second end connector.

**2**. The compliant connector adapter of claim **1**, wherein the compliant mount body has enough rigidity to support the portable device when the second end connector is matingly engaged with the other electronic device and the first end connector is matingly engaged with the portable device.

**3**. The compliant connector adapter of claim **1**, wherein the other electronic device comprises a docking station and the adapter has a length sufficient to extend the first end connector above a docking well of the docking station in which the second end connector is disposed when matingly engaged with the docking station so as to allow coupling of a portable device with the docking station, wherein the docking well is of insufficient size to receive the portable device.

**4**. The compliant connector adapter of claim **1**, wherein the plurality of electrical contacts of the first end connector are arranged in a first configuration and the plurality of electrical contacts of the second end connector are arranged in a second different from the first configuration.

**5**. The compliant connector adapter of claim **4**, wherein the first configuration comprises an eight-pin connector and wherein the second configuration comprises a 30-pin connector.

**6**. The compliant connector adapter of claim **1**, wherein the first end connector comprises a connector tab insertable into a corresponding connector receptacle of the portable electronic device, and wherein the second end connector comprises a connector receptacle configured to matingly receive a corresponding connector tab protruding from the other electronic device.

**7**. The compliant connector adapter of claim **1**, wherein the compliant mount body has one or more springs.

**8**. The compliant connector adapter of claim **7**, wherein the one or more springs are configured to resist bending or torsional movement between the first and second end connector until a pre-determined load is exceeded after which the one or more springs allow increased bending or torsional movement between the first and second end connectors.

**9**. The compliant connector adapter of claim **7**, wherein the compliant mount has one or more torsion bars extending between the first and second end connectors.

**10**. The compliant connector adapter of claim **1**, wherein the compliant mount comprises an elongate cylindrical member extending laterally outward from a base portion of the first end connector, wherein the elongate cylindrical member is rotatable about a longitudinal axis of the elongate cylindrical member such that the first connector pivots about the longitudinal axis when the elongate cylindrical member is rotated.

**11**. The compliant connector adapter of claim **10**, wherein the elongate cylindrical member is configured to provide translation and/or rotational movement in one or more other directions than a direction of rotation about the longitudinal axis.

**12**. The compliant connector adapter of claim **10**, wherein the elongate cylindrical member is coupled with a helical spring.

**13**. The compliant connector adapter of claim **12**, wherein the helical spring is configured so that the elongate cylindrical member is biased toward an upright position of the first connector.

**14**. The compliant connector adapter of claim **13**, wherein the helical spring is configured so that the helical spring provides increased resistance to movement of the elongate cylindrical member when the first connector is moved away from the upright position.

**15**. A compliant connector adapter for connecting a portable electronic device with an other electronic device, the adapter connector configured to enable data and power transmission between the electronic devices, the adapter connector comprising:

a first end connector and second end connector, the first end connector having a plurality of electrical contacts to enable data and power transmission therethrough and being configured to enable said data and power transmissions to pass between the portable electronic device and the second end connector, the first end connector further configured for removable mating engagement with the portable electronic device, and the second end connector having a plurality of electrical contacts arranged to enable data and power transmission therethrough and being configured to enable said data and power transmissions to pass between the other electronic device and the first end connector thereby enabling said data and power transmissions to pass between portable electronic device and the other electronic device, the second end connector further configured for removable mating engagement with the other electronic device, and

a compliant mount body coupling the first end connector and second end connector so as to support the first end connector when the second end connector is matingly engaged with the other electronic device, wherein the compliant mount body is sufficiently flexible to allow relative movement of the first end connector relative to the second end connector, wherein the compliant mount body comprises an elongate tube rotatable about an axis substantially perpendicular to an insertion axis of the first end connector to allow a compliant bending movement and a helical spring coupled to the elongate tube that limits the compliant bending movement.

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